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STUDIES OF THE SMALLMOUTH BASS

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In Ontario the smallmouth bass (*Micropterus dolomieu*) reaches a limit of its native geographic range. In the southern part of the province it is naturally abundant and of widespread occurrence. In the north its distribution is limited, and the northern boundary of its range is well defined (Hubbs and Bailey, 1938, p. 27). In several waters, chiefly in the north, bass are now present as a result of artificial plantings. These introductions have developed with different degrees of success. In some lakes the bass have become firmly established and have thrived; in others, the new waters proved to be unsuitable, and the introductions were partially or completely unsuccessful.

The present distribution of the smallmouth bass offers an excellent opportunity for studies of factors governing the existence of a species, and of the ecological relations that influence such activities as feeding, growth, and reproduction. The basis of these investigations has been field observation, supplemented by laboratory treatment of the data. The studies of bass in separate waters also have been integrated into an ecological whole, that is, they have been related in a general consideration of the life history of the bass and some of the factors affecting its welfare. Among these are: nature of the water, temperature, food, substrata, predators, and competitors. Some of these depend upon the geographical position and climatic conditions in which a given body of water is situated, others on the physical characteristics of the lake or river and its inhabitants, and still others may be brought about by economic use of the bass by man.

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METHODS AND APPARATUS

The basis of these studies of wild smallmouth bass under different ecological conditions has been field observations. Some of these were made in May and June when the bass had become active to the point of spawning; others continued throughout the year. Locations of bass nests were determined by noting guarding adults or nest depressions, both from shore and boat. Measurements of nest dimensions and depth of water were made with a yardstick. Sampling of nests was accomplished by sucking material into a length of glass tubing, the contents of which were then spread out on a flat surface, and eggs or fry transferred to vials of 70 per cent alcohol. Eggs and fry were measured by means of a sliding stage microscope and micrometer, capable of measurements to the nearest tenth of a millimeter.

Small free-swimming fry were collected by the use of an ordinary kitchen sieve, advanced fry and fingerlings were taken in a seine. Immature and adult bass were caught by angling and by the use of fyke nets. Growth of bass older than fingerlings has been determined from length and weight measurements of freshly caught specimens, and laboratory examination of the scales at a later date for age determinations. Scales were removed from the side of the fish in the mid-region, either above or below the lateral line. The age in August, 1940, of a fish hatched in June, 1937, would be about 38 months, and a scale of the fish would show three winter "rings"; the fish is said to be in its fourth year of life, and its age is written IV.

Total length was taken as the distance in inches from the tip of the closed lower jaw to the center of the fork of the tail. Standard length is the distance in centimeters from the tip of the closed lower jaw to the end of the vertebral column, usually measured to the base of the caudal fin. Weights were taken to the nearest quarter ounce.

Most organisms from stomach contents were identified and measured at the time of examination in the field. On some occasions, only the lengths of certain organisms were recorded; at a later date, from known relationships (Solman, 1936), these lengths were converted into approximate volumes.

For purposes of the food study, the bass have been arbitrarily divided into seven classes according to length, by three-inch intervals. Percentage frequency and percentage volume calculations, and figures expressing the total stomach content volume per 100 fishes, are based only upon the stomachs containing food.

WATERS UNDER INVESTIGATION

These studies on the smallmouth bass present data that have been collected from Lake Erie to Lake Nipissing nearly 300 miles north, and from Lake Huron on the west to the Ottawa River region 275 miles to the east. The following annotated list of names of lakes and rivers has been drawn up for reference purposes. The location of some of the waters, as well as of the larger districts mentioned in the text, are indicated in Fig. 1.

Lake Erie. Bass were taken from the vicinity of the Bass Islands in the western end of the lake, Ottawa County, Ohio, where there are numerous lime-

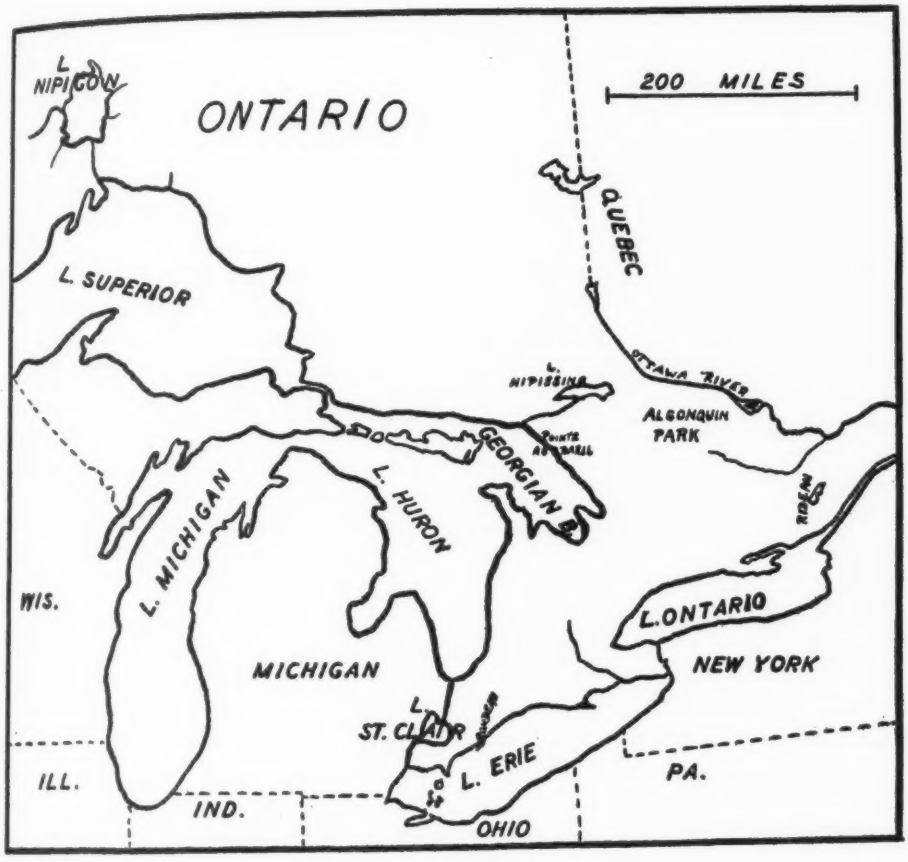

Fig. 1. Map of southern Ontario.

stone shoals and islands. A few specimens were examined from Rondeau Bay, Kent County, Ontario, a nearly completely enclosed body of water of about 7,000 acres, marshy in character and fished by many anglers.

Lake St. Clair. Mitchell's Bay is the northeast part of the lake, bordering on the counties of Kent and Lambton, Ontario. Approximately 75 per cent of the area of the bay has a depth of less than six feet, and only three per cent is as deep as 12 feet. The shores are low and marshy, and aquatic vegetation is abundant. The bay receives a supply of cold, fresh water from branches of the St. Clair River that enter along the north shore. Angling is important in the more accessible parts of the bay.

Lake Huron. The bass studied were taken near Oliphant, Township of Amabel, County of Bruce, Ontario. The shore in this region is rocky and there are many islands.

Georgian Bay. This is the eastern part of Lake Huron, fronting on the districts of Parry Sound and Muskoka, and is about 150 miles in length. The shoreline

is rocky, irregular, has many islands and shoals, and the offshore water is deep. There are colonies of summer residents in certain localities, settlements being fewer in the northern parts. Georgian Bay is heavily fished by anglers, more especially in the vicinity of summer cottages.

Lake Nipissing. This is a shallow lake of 345 square miles, and extends west from the town of Callander in the district of Nipissing. The lake is mostly open, but includes several bays and a few groups of islands. Organisms serving as food for bass are present in abundance.

Found Lake. This small bog lake has an area of about 20 acres, and is in the Township of Peck, District of Nipissing, Algonquin Park. Bass were introduced at an unknown date. Minnows are extremely scarce.

Cache Lake. This lake is in the Township of Canisbay, Algonquin Park, near the headwaters of the Madawaska River, and at an elevation of 1,406 feet. Bass were introduced in 1899. Cache Lake is two miles long and about 700 acres in extent, and has rocky shores. About 90 summer cottages, a summer camp, and two hotels are located on the lake, and fishing has been intensive for many years. Lake trout (*Cristivomer namaycush*) and smallmouth bass are the only game fishes; a few minnows and crayfishes are present.

Madawaska River. The section of this river from which bass were taken is that part immediately below the dam at Cache Lake. The river is rocky, about 10 feet in width in the summer, shallow, and consists, at this point, of pools and intervening rapids. It is moderately fished.

Lake Opeongo. In the townships of Bower, Sproule, and Dickson, is the largest lake in Algonquin Park, with a length of about nine miles and an area of 13,500 acres. For the most part the shores are rocky. Bass have been present in the lake for between 15 and 20 years, having found access, it is believed, through the Opeongo River. Minnows are not abundant, but can be found in sheltered bays. The lake is heavily fished in the summer, chiefly for lake trout.

Booth Lake. This lake of about three miles in length, and approximately 800 acres in area, is on the Opeongo River, Algonquin Park. It is said that bass were first noted about 30 years ago. A few anglers visit Booth Lake each summer.

Wright Lake. This lake also is in Algonquin Park, in the Township of Dickson. It has a length of 1½ miles and an area of 175 acres, and is visited by only a few summer anglers.

Lake Traverse. Situated in the northern part of Algonquin Park, in the townships of White and Edgar, Lake Traverse is open and shallow, three miles in length, and has an area of about 1,000 acres; it is formed by expansion of the Petawawa River. Smallmouth bass, maskinonge (*Esox masquinongy*), and wall-eyed pike (*Stizostedion vitreum*) are present. Considerable angling is centered at a fishing camp on the lake.

Petawawa River. The bass studied were taken from below the dam at the foot of Lake Traverse. The river is rocky, with many rapids.

Meach Lake. This lake is in the Township of Hull, County of Hull, Province of Quebec, and is about 800 acres in extent. According to J. A. Rodd of

Ottawa, the lake is rocky, the smallmouth bass were introduced, and minnows are very scarce.

GROWTH

Although the smallmouth bass has been appreciated as a game fish for many years, only recently has the species been the subject of scientific study in any of the waters named. In a paper on the spawning of bass in Ontario, Tester (1930) presented data illustrating the growth of fry from one of the nests under observation in Lake Nipissing in 1930. He found that bass fry doubled in length about three weeks after hatching. These data have here been included for purposes of comparison.

From a detailed investigation of the growth of gill filaments of the smallmouth bass of the island region of Lake Erie, Price (1931) concluded, among other things, that the rate of formation of the filaments gradually decreased with increase in the total length of the bass, and that the number of filaments became nearly constant at 2,000 at lengths of 30 centimeters and more. He studied also the relative growth of the length of the filaments in relation to their depth and width, and of the surface of the gills to body size.

Tester (1932b) reported that the rate of growth in length of bass in Lake Nipissing was more rapid and in Georgian Bay less rapid than in Perch Lake. In the latter lake, a small body of water near Lake Nipissing, the bass attained a length of 10 inches in their fifth year. Female bass in Perch Lake appeared to increase in length at a slightly slower rate than males. The values of K, the coefficient of condition of bass in different waters, were calculated from the formula, $K = 100W/L^{3.17}$, where W is the weight in grams, L the length in centimeters, and 3.17 represents the power of the length by which the weight increased in Perch Lake. The values of K were found to be, Perch Lake 1.3(8), Lake Nipissing 1.5(8), Phantom Lake 1.3(8), and Georgian Bay 1.6(7), and a correlation between slow growth and higher coefficient of condition was noted. The existence of dominant year classes was demonstrated.

Hubbs and Bailey (1938) gave some consideration to conditions under which bass live in the northern sections of their range, and made reference also to Lake Erie. In a preliminary report on investigations in southwestern Lake Erie, it was shown (Doan, 1938) that bass grew to a length of 10 inches in their fourth summer, that larger bass ate mostly fish and some crayfish, and that angling in the early autumn resulted in the taking of larger bass than did summer angling.

A study of the relative growth of parts of bass fry (Doan, 1939) taken from Lake St. Clair indicated that the relation between the growth of these parts and that of the standard length was logarithmic; the values of this relation altered, at a standard length of 9.6 mm., for the diameter of the eye and the length of the head, which decreased in growth rate, and at a standard length of 12.9 mm. for the lengths of the anal and pectoral fins, the former of which increased in growth rate. A fall in water temperature from 73° to 58.5°F. over a three-day period was associated with a decrease in the rate of growth of parts of bass fry as well as of their total length.

TABLE 1

AVERAGE LENGTH MEASUREMENTS (MM.) OF SMALLMOUTH BASS FRY FROM ONE NEST IN LAKE ST. CLAIR IN 1935, SEVEN IN LAKE ST. CLAIR IN 1936, SIX IN GEORGIAN BAY, NEST IN LAKE NIPISSING (TESTER), AND ONE NEST IN CACHE LAKE.

Date	Lake St. Clair (Mitchell's Bay)		Georgian Bay	Lake Nipissing	Cache Lake
	1935	1936	1936	1930	1937
June 4		8.9			
5		9.1			
6		9.4			
7		9.7			
8		10.1			
9		10.6			
10		11.1			
11		11.6		5.7	
12	10.6	12.3		6.1	
13	10.7	13.1			
14		13.9		6.9	
15	12.3	14.4			
16		15.0		7.4	
17		15.4			
18	14.3	15.9		8.0	
20				8.7	
21	14.7				
22				9.1	
23	16.1		8.3		
24	16.0		8.4		9.2
25			8.6		
26	17.4		8.9	10.5	
27	18.0		9.2		
28	19.2		9.6		
29	20.1		9.8		
30			10.1	11.6	
July 1			10.3		
2			10.6		
3			10.9		
4			11.3	13.4	
5			11.7		
6			12.2		
7			12.8		
8			13.4	16.2	
9			14.1		
10			14.9		
12				19.8	

GROWTH OF FRY

In studying the growth of bass fry, it was desired to learn how much young bass grew in a given time in a certain body of water, in various years, and also how growth differed in other waters.

In Lake St. Clair growth of bass fry was studied in 1935 from a series of samples taken from a nest in Mitchell's Bay. In 1936, 11 nests were placed under intensive observation, and samples taken from each at two-day intervals. Mean growth measurements have been derived from individual graphs of the growth of young bass from each of these 11 nests. The growths of fry, during both years, have been included in Table 1 and in Fig. 2. The Mitchell's

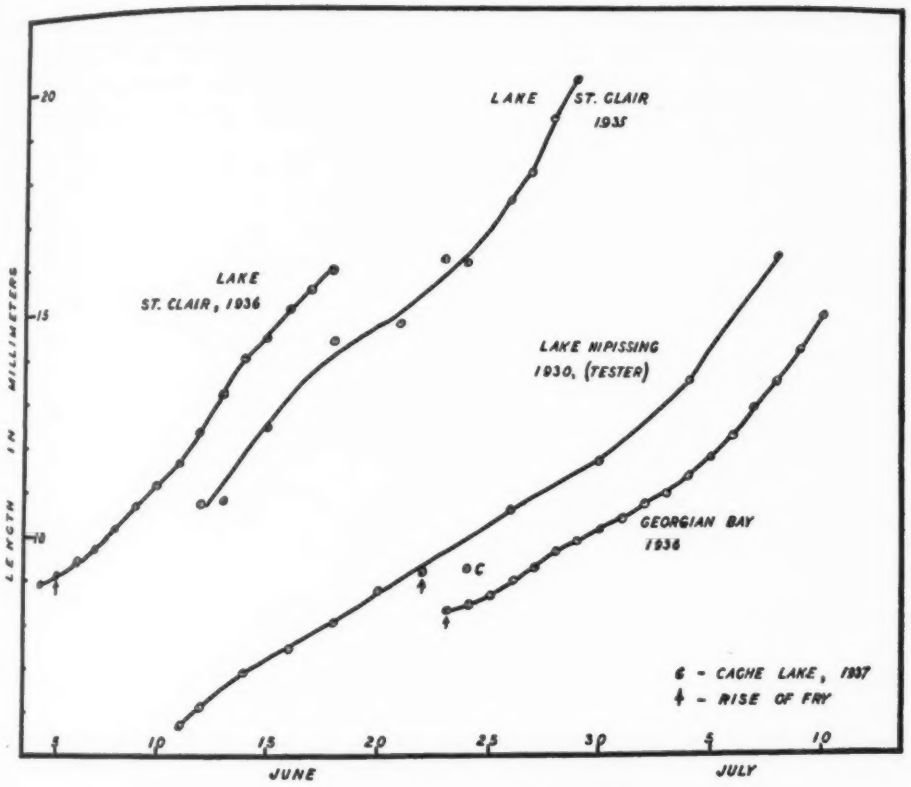

Fig. 2. Growth of smallmouth bass fry.

Bay fry were in advance of those from all other waters investigated, probably due to earlier nesting.

In Georgian Bay, growth of fry received attention in the Pointe au Baril region in 1936. Eleven nests were sampled at intervals throughout a period of three weeks. It was noted again, as in Mitchell's Bay, that checks in the rate of growth of young bass were associated with drops in water temperature. The Georgian Bay fry were the most retarded of those studied.

In Cache Lake, the only data pertaining to the size of bass fry were obtained from a single collection from one nest, made June 24, 1937. Fourteen young bass had an average total length of 9.2 mm.

Bass fry in Lake St. Clair in 1936 rose from the nest bottoms at an average length of 9.1 mm., those in Georgian Bay at 8.3 mm., and those in Lake Nipissing (Tester) in 1930 at 9.1 mm. The young fry doubled in length in all waters in from 17 to 20 days after rising. In 1936 the development of young bass in Mitchell's Bay was about three days earlier than in 1935 in the same locality. Further, the growth in Mitchell's Bay in 1936 was about 2½ weeks ahead of that of young in Lake Nipiss-

ing in 1930, and was over three weeks in advance of that in Georgian Bay in 1936.

GROWTH OF FINGERLINGS

The term "fingerlings" has been applied to young bass varying in length from about one inch to the maximum average attained during their first summer, 3.3 inches among the specimens measured. Total lengths of bass in their first summer have been obtained from specimens collected from miscellaneous sources, and preserved in the Royal Ontario Museum of Zoology.

The spread between dates on which all fingerlings attained a given length was about one month. In Lake Nipissing wide variation in fingerling growth may occur in different years: the bass from this lake in 1934 were about three weeks in advance of those taken at comparable stages in 1932 (Table 2). The growth of bass in a particular body of water during their first summer is not indicative of the growth of adults there.

TABLE 2

GROWTH OF SMALLMOUTH BASS FINGERLINGS

Water	Year	Date	No. of fish measured	Average total length, inches	Average standard length, mm.
Lake Nipissing	1932	July 11	4	0.7	15
		July 21	3	1.1	24
		July 24	1	1.3	28
		Aug. 11	1	1.9	41
		Aug. 24	1	2.7	61
	1934	July 4	4	1.0	22
		July 13	1	1.3	28
		July 20	4	1.9	42
		Aug. 30	1	2.6	56
Cache Lake, Algonquin Park	1935	July 12	1	1.2	25
		July 29	11	2.1	47
		Aug. 8	3	2.6	56
Canoe Lake, Algonquin Park	1935	Aug. 25	2	2.1	47
Lake Traverse, Algonquin Park	1936	July 16	2	1.2	26
Rideau Canal, Merrickville, Grenville County	1937	Aug. 26	7	3.3	71
Rideau River, near Ottawa	1937	Aug. 31	3	2.8	60
Beverage's Creek, Parry Sound	1937	July 29	5	2.2	47

In Lake St. Clair, measurements and scales were obtained from 283 fish caught by anglers in Mitchell's Bay between June 25 and July 6, 1935. According to this sample, bass hatched in 1931 constituted the largest single year class, amounting to about 50 per cent of the total (Table 3). The fish in this lake were among the fastest growing of those studied (Fig. 3). From Lake St. Clair, scales and measurements of 36 bass were obtained in 1936. Growth determinations agreed closely with those made the previous year. Again bass hatched in 1931 continued to dominate

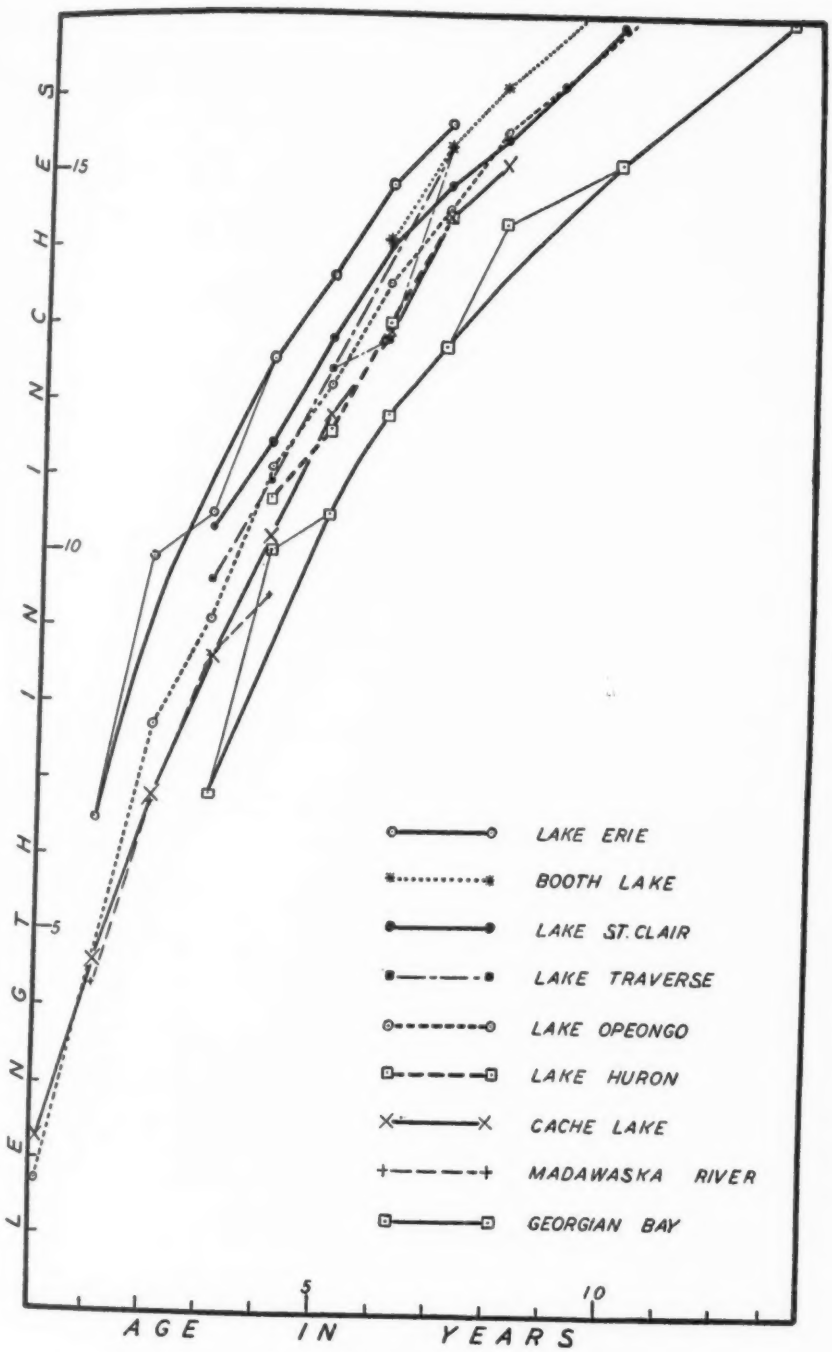

Fig. 3. Growth of smallmouth bass.

TABLE 3

AVERAGE MEASUREMENTS AND DETERMINATIONS OF AGES, SEXES AND YEAR CLASSES IN SMALLMOUTH BASS

Year	Lake	In year of age	Average total length, inches	Average standard length, cm.	Average weight, ounces	No. of fish			Year classes	
						♂	♀	Both sexes	No. fish	%
1935	St. Clair (Mitchell's Bay)	IV	10.3	22.3				11		4
		V	11.4	24.8				142		50
		VI	12.9	28.0				107		38
		VII	13.9	30.4				14		5
		VIII	14.8	32.1				9		3
1936	St. Clair	V	11.4					4		
		VI	12.8					20		
		VII	14.1					5		
		VIII	14.9					3		
		IX	15.4					1		
		X	16.1					2		
		XI	16.9					1		
1938	Erie	II	6.5	14.4	2.9			21		7
		III	9.9	21.7	9.8	7	6	13		4
		IV	10.5	23.1	11.5	47	55	102		33
		V	12.5	27.3	18.5	54	55	109		35
		VI	13.6	29.9	26.0	25	23	48		16
		VII	14.8	32.5	33.5	4	10	14		5
		VIII	15.6	34.4	34.7	0	1	1		
1935	Erie (Rondeau Bay)	VI	12.4	26.8				4		
		VII	13.3	28.9				1		
1937	Huron	V	10.7					4		12
		VI	11.6					15		46
		VII	13.0					10		30
		VIII	14.4					4		12
1936	Georgian Bay	IV	6.8	14.8	2.7	1		6		6
		V	10.0	22.0	9.3	6	2	9		9
		VI	10.5	23.2	10.8	21	10	32		34
		VII	11.8	25.7	15.3	13	14	27		28
		VIII	12.7	27.9	19.8	8	6	14		15
		IX	14.3	31.2	28.6	1	3	4		4
		XI	15.1	33.4	32.0	1	1	2		2
		XIV?	17.0	37.4	46.0		1	1		1
1935	Found	III	7.4	16.2	2.8			1		
		IV	8.4	18.4	4.3			1		
		V	9.5	21.1	7.4			2		
		VI	9.8	21.5	8.5			1		
1935 and 1936	Cache	I	2.3	4.9				15		
		II	4.9	10.7	1.0			11		
		III	6.8	14.8	2.6			36		
		IV	8.3	18.0	5.1			22		
		V	10.4	22.7	9.4			20		
		VI	11.9	25.9	15.1			3		
1937	Cache	II	4.0	10.0	1.1			5		
		III	6.8	14.9	2.8			13		
		IV	8.5	18.7	5.5			30		
		V	10.0	21.9	8.9			21		

TABLE 3 (Continued)

Year	Lake	In year of age	Average total length, inches	Average standard length, cm.	Average weight, ounces	No. of fish			Year classes	
						♂	♀	Both sexes	No. fish	%
		VI	11.7	25.6	15.1			7		
		VII	12.9	28.3	21.5			4		
		VIII	14.4	32.0	25.5			1		
		IX	15.1					1		
1935	Cache	II							7	10
		III							29	43
		IV							9	13
		V							20	29
		VI							3	4
1936	Cache	II							4	17
		III							7	29
		IV							13	54
1937	Cache	II							14	4
		III							107	29
		IV							158	43
		V							58	16
		VI							21	6
		VII							11	3
		VIII							1	
		IX							1	
1935	Madawaska River	II	4.3	9.7	0.8				1	1
		III	6.7	14.5	2.2				33	38
		IV	8.6	17.7	4.2				30	35
		V	9.4	20.2	6.2				23	26
1936	Madawaska River	II							1	
		III							2	
		IV							2	
		V							2	
		VI							1	
1937	Madawaska River	III							13	35
		IV							19	51
		V							2	5
		VI							3	8
1936	Opeongo	I	1.7	3.6				9		6
		III	7.7	16.8	4.6	3	2	7		5
		IV	9.1	20.0	8.0	13	9	25		18
		V	11.1	24.1	13.5	11	10	21		15
		VI	12.2	27.0	19.3	22	25	47		33
		VII	13.5	29.8	25.4	13	13	26		18
		VIII	14.5	31.8	32.3	3	3	6		4
		IX	15.5	33.8	36.0		1	1		1
		XII	17.5	38.3	62.0		1	1		1
1937	Opeongo	V							24	14
		VI							42	24
		VII							45	26
		VIII							51	30
		IX							10	6

TABLE 3 (Continued)

Year	Lake	In year of age	Average total length, inches	Average standard length, cm.	Average weight, ounces	No. of fish			Year classes	
						♂	♀	Both sexes	No. fish	%
1936 and 1937	Booth	VII	14.1					12		
		VIII	15.3					6		
		IX	16.1					2		
		XI	17.5					1		
		XII	18.3					1		
1936	Wright	VII	14.7	32.1				2		
		VIII	16.3	35.2				1		
		XIII?	19.0	42.2				1		
1936	Traverse	IV	9.6	21.0	8.0			1		
		V	10.9	23.8	10.5			5		
		VI	12.4	27.5	17.8			1		
		VII	12.8	28.0	18.5			2		
		VIII	15.3	33.5	35.3			3		
1936	Petawawa River	IV	9.1	20.0	6.3			1		
		V	10.2	22.8	9.8			3		
		VII	13.0	28.3	16.5			1		
1937	Meach	III	6.1		1.8			1		
		IV	8.8		5.2			5		
		V	10.5		8.9			2		

the catches, amounting to more than 50 per cent of the total.

From the island region of Lake Erie examination was made of the scales of 308 bass that had been caught and measured during the summer of 1938. These fish showed faster growth than did those from any other water studied. They attained a length of 10 inches in their third or fourth year of life, at which time they weighed about 10 ounces. These bass weighed a pound at slightly less than 12 inches and had a weight of two pounds at an average length of $14\frac{3}{4}$ inches. The length attained by two-year old fish in October of their third year was the same as that recorded for three-year old fish near the beginning of July of their fourth year. Three-year old fish in the autumn were approximately the same length as four-year olds early in their fifth summer. In the older year classes the differences between autumn and early summer lengths of consecutive year groups was greater. This would seem to suggest that younger bass do not grow as much during the winter as do the older fish. The sexes were evenly divided in all year classes, with the possible exception of the sixth of which very few specimens were examined.

In Rondeau Bay, Lake Erie, examination of a few bass caught on June 30, 1935, indicated a rapid rate of growth, but, nevertheless, lower than that of fish from the island region.

From Lake Huron, there were available scales and measurements of 33 bass collected by the Grey and Bruce Game and Fish Protective Association in 1937. Although living in a part of the

same greater water area, the bass of Lake Huron showed a faster growth than did those from its eastern division, Georgian Bay.

In that Bay, data pertaining to 95 fish were collected in July, 1936. These fish showed the poorest growth of any in all the waters sampled. Males in their sixth year averaged longer and heavier than did females of the same age. Tester had examined 26 specimens from Georgian Bay in 1928, and from a comparison with his results it would appear that the bass had made better growth during the few years preceding 1936 than in those just before 1928. However, a comparison of scale readings has been made, and allowance for a difference of a year, especially in the older age classes, would make the results about the same for the 1928 investigations as for those of 1936.

A study of the growth of 107 smallmouth bass in Cache Lake was made during the summers of 1935 and 1936. Further collections of data on 82 individuals were made in 1937, and it was concluded that the species did not make good growth in this lake. When the catches were divided into year classes, it was seen that certain of these classes predominated over others for one or more seasons. The year classes of 1933 and 1931 were foremost in the catch of 1935, that of 1933 continuing to be outstanding in 1936. However, in 1937 the dominant year classes of the previous two seasons were superseded by that of 1934.

From the Madawaska River, 87 bass were taken in 1935. Poor growth had been made by these fish also, and, although of some dominance, the year class of 1933 was not particularly outstanding. Further collections of 45 specimens were made in 1936 and 1937, in an effort to trace succession in dominant year classes. The number taken in 1936 was too meager to permit significant conclusions, but in 1937 the year class of 1934 was dominant. The presence and succession of dominance in the year classes of 1933 and 1934 in the bass of the Madawaska River below Cache Lake closely parallels those of bass in the lake itself.

In Lake Opeongo examination of 143 bass was made during August and early September of 1936. These fish had undergone good growth. The dominant year class was that of bass in their sixth summer, hatched in 1931. A lesser dominance was in evidence, namely, that of fish in their fourth summer, hatched in 1933. Although males and females, at a given age, did not differ greatly in average length, there was a tendency for the weight of females to exceed that of males by about one ounce. During the summer of 1937 members of the Laboratory at Toronto examined 172 bass taken by anglers. The year classes of 1932, 1931, and 1930 were about equal in dominance, that of 1930 being slightly ahead.

The numbers of bass taken from each of the remaining waters are not sufficient to warrant more than passing comment on the rate of growth. Bass growth was poor or below average in Found Lake, Meach Lake and the Petawawa River, better than average in Lake Traverse, and very good in Booth and Wright lakes.

In summary, growth of smallmouth bass has been studied in 13 waters in Ontario and Ohio, and one in Quebec. The most rapid growth was shown by

fish in Lake Erie, and the slowest by those in Georgian Bay. It was found that bass living in Cache, Found, and Meach lakes did not achieve as good growth as did specimens from certain other waters. The bass in these three more northern rocky lakes are living in waters to which they are not native.

Evidence of the existence of dominant year classes has been given further support, and it has been shown that such classes may maintain their dominance for at least two years. The year classes of 1931 and 1933 were outstanding in anglers' catches in several of the waters studied. In special instances, differences in the rates of growth of male and female bass were noted, but no trend in that direction was demonstrated.

FOOD

As with studies of growth, those of the food of smallmouth bass in Ontario have been few. Some of the earlier scientific surveys, about 20 years ago, incidentally recorded the food of a few bass. Bensley (1915) reported that the staple food of smallmouth bass in Georgian Bay consisted of crayfishes, supplemented by minnows, and that young bass fed on plankton entomostraca.

Wickliff (1920) published one of the most important food studies on small bass. He examined 313 specimens (0.85 to 6.5 cm.) taken from the western end of Lake Erie, in the vicinity of the Ohio islands. Copepods were found in 61 per cent, cladocerans in 40, chironomid larvae in 20, chironomid pupae in 27, ephemerid nymphs in 12, adult insects in 25, fish in 18, and crayfish in one per cent of the stomachs. He said: "The food cycle seems to be copepods and cladocerans of an almost pure diet to 15 mm.; then from 16 to 45 mm. mixed with these are mayfly nymphs, midge larvae and pupae, with fish and adult insects; and above 45 mm. fish, adult insects and crayfish are important."

Clemens and others (1923) recorded the food of six bass (2.6 to 3.3 cm.) in Lake Nipigon as Copepoda; Cladocera; aquatic insect larvae, nymphs, pupae, and adults; and fish remains. Clemens, Dymond, and Bigelow (1924) recorded the food of three bass (3.0 to 3.4 cm.) from Lake Nipigon, taken July 31, as fish 90–95 per cent, and Ephemeridae, Chironomidae, *Cyclops*, *Latona*, and *Corixa* together 5–10 per cent.

Tester (1932a) presented results of food studies of bass in some Ontario waters, and stated that in large bodies like Georgian Bay and Lake Nipissing the food of adult bass consisted of about 75 per cent crayfish and 25 per cent fish, with a negligible percentage of insects. Large adult bass tended to eat a larger percentage of fish than did small adults. In smaller lakes, insects were found in a greater proportion of the stomachs. The importance of copepods and cladocerans, as well as of insect larvae, in the diet of small bass was shown; these forms were replaced by fish and crayfish as the bass became larger. Results of examination of bass from two rivers, the Grand and the Ortongue, indicated that fish in these habitats probably ate a larger percentage of insects. Tester also gave a good summary of investigations dealing with the food of bass in the United States.

In the present study 221 fish from Lake Erie were used in analyses of the food of smallmouth bass. Minnows composed most of the food, and increased in volume and frequency as

the bass grew (Table 4). Crayfish, the other chief food item, decreased in importance with increase in the size of the bass. Insects, at no time during the investigation (July to October, 1938) of any importance in the diet of the Lake Erie bass of the sizes under consideration, decreased in the stomach contents with increase in bass size. The chief food minnow was the lake shiner, *Notropis atherinoides*, but occasionally *Stizostedion vitreum*, *Perca flavescens*, *Lepibema chrysops*, *Aplodinotus grunniens*, and *Percina caprodes* also were eaten by smallmouth bass.

TABLE 4

FOOD OF SMALLMOUTH BASS IN LAKE ERIE, 1938

Size class, inches	No. of fish examined	Empty stomachs		Minnows				Crayfish				Insects				Volume of food per 100 bass, cc.
				Per stomach		Percentage		Per stomach		Percentage		Per stomach		Percentage		
		No.	%	No.	Vol., cc.	Fre.	Vol.	No.	Vol., c.c.	Fre.	Vol.	No.	Vol., c.c.	Fre.	Vol.	
6–9	16	2	13	0.9	1.2	71	68	0.7	0.6	36	32	0.07	0.01	7	0.4	176
9–12	111	22	20	2.3	2.9	82	75	0.6	0.9	34	25	0.02	0.01	2	0.1	384
12–15	90	38	42	2.0	3.9	83	87	0.7	0.6	31	13	0.02		2	0.1	454
15–18	4	2	50	2.0	4.0											

Although the number of minnows consumed averaged nearly two per bass the volume of minnows taken rose from 1.2 cc. to 4.0 cc. with increase in the size of the bass. As to crayfish, bass of 6–9 inches ate about the same numbers and volumes as did those of 12–15 inches in length. But, the bass of 9–12 inches ate slightly fewer crayfish, and those taken were of a larger average size. The amount of food in the stomachs increased from 176 cc. per 100 fish in the 6–9 inch group to nearly three times that amount in the 12–15 inch group. A weight increase of 2.5 times (from 6–9 to 9–12 inches) was associated with the presence of 2.2 times as much food in the bass stomachs, and the next doubling (2.1) of weight (from 9–12 to 12–15 inches) with the presence of but 1.4 times as much food. Thus, the interval from $7\frac{1}{2}$ to $13\frac{1}{2}$ inches represents a weight increase of about 5.3 times, yet only 3.1 times as much food was present in the stomachs of the larger as in those of the smaller bass. The incidence of empty stomachs increased with the size of the bass, so that at 15–18 inches bass with no stomach contents were about four times as frequent as in the 6–9 inch group.

The stomach contents of 93 immature and adult bass from Georgian Bay were analyzed during July, 1936 (Table 5). The ratio of bass with empty stomachs to those containing food decreased with the size of the bass. While the number of bass of the 6–9 inch size class examined was so small that a mathematical statement of average food quantities is not significant, the data obtained are given for what they are worth. Of two stomachs with contents, one contained 2.2 cc. of fish, and the other a fish of 0.3 cc. in bulk and a dragon fly nymph of 0.3 cc. Of the three bass in the 15–18 inch class, one held a crayfish of 1.5 cc., another 4.0 cc. of fish, and the third 1.2 cc. of fish. For this largest

size class, fish were nearly 80 per cent of the food.

In both the 9–12 inch and the 12–15 inch size classes also, fish occurred with the highest frequency and provided the greatest bulk in the bass stomachs. A decrease in the amount of crayfish consumed, with a corresponding increase in the amount of fish, was noted as the bass increased in average size past 9–12 inches. This finding is in agreement with that of Tester for Lake Nipissing and Georgian Bay, that "large adult bass tend to eat a larger percentage of fish than [do] small adult bass." The insects taken as food were the nymphal stages of several odonates. The fish eaten were chiefly perch (*Perca flavescens*); the group "miscellaneous" refers to a deermouse (*Peromyscus*) found in the stomach of one bass. The amount of food found in the stomachs of bass 9–12 inches in length was 65 per cent of that found in the stomachs of fish averaging three inches more in length; the ratio is approximately two to three.

The stomachs of 80 bass collected in Cache Lake during the latter part of the summers of 1935 and 1936 have been examined (Table 6). The percentage of empty stomachs ranged from 30 to 38 in all the size classes. Plankton and insects were the chief items of food for the yearling and small immature bass, being replaced by fish and crayfish as the bass grew larger. Crayfish formed the chief food of the larger bass. The ratios of the volumes of food per 100 stomachs containing food is 1:2 when the 3–6 and 6–9 inch size classes are compared, and is 1:3 in the 6–9 and 9–12 inch groups.

From Lake Opeongo, the stomachs of 134 bass were analyzed during the summer of 1936 (Table 6). The smaller bass of 6–9 inches fed chiefly on crayfish, with lesser amounts of fish and aquatic insects in addition. Bass longer than nine inches subsisted almost exclusively upon crayfish, with fish playing a lesser part in the food supply, insects being negligible. It was noted that the largest bass examined had eaten chiefly not fish, but crayfish, contrary to what was observed in the Georgian Bay specimens. More fish with empty stomachs were present in the 6–9 inch, than in the other, classes; the class 15–18 inches is excluded because of lack of data. The 6–9 inch fish yielded an average of 2.4 cc. of food per stomach containing food, which was about 57 per cent of the

TABLE 5

FOOD OF SMALLMOUTH BASS, GEORGIAN BAY, 1936

Size class, inches	Incidence of food in stomachs of bass of various sizes				Analyses of Food					
	No. of stomachs examined	No. of empty stomachs	% empty	Ratio no. empty / no. with contents	Food item	Number of stomachs containing food item	% frequency	Volume of the food item, cc.	% vol.	Volume of stomach contents per 100 stomachs, cc.
6–9	7	5	71	2.5						(140)
9–12	57	31	54	1.2	Crayfish	12	46	40.6	40	
					Fish	16	62	58.3	57	393
					Insects	8	31	3.3	3	
12–15	26	7	27	0.4	Crayfish	8	33	31.4	27	
					Fish	15	63	77.5	68	605
					Misc.	1	4	6.0	5	
15–18	3	0	0	0.0						

amount contained in the stomachs of 9–12 inch fish, that in turn being 55 per cent of the average amount of food in the stomachs of 12–15 inch fish.

The few bass stomachs examined from Found Lake indicate that here the smaller immature bass fed principally upon the nymphs of aquatic insects, and the larger immature bass ate chiefly crayfish, with a few insects in addition.

had eaten crayfish and a dragonfly. A single bass in the 12–15 inch group was empty. Insects, both aquatic and terrestrial, composed most of the food of bass in the Petawawa River below Lake Traverse, with smaller amounts of fish and crayfish in addition.

GROWTH AND FOOD

Previous studies have shown the importance of copepods, cladocerans, and

TABLE 6

FOOD OF SMALLMOUTH BASS IN CACHE LAKE, 1935 AND 1936, AND IN LAKE OPEONGO, 1936

Size class, inches	No. of bass examined	Empty		Total stomach volume per 100 bass, cc.	Plankton		Insects		Crayfish		Fish		Frogs	
		No.	%		% fre.	% vol.	% fre.	% vol.	% fre.	% vol.	% fre.	% vol.	% fre.	% vol.
Cache Lake														
3– 6	10	3	30	73	29	43	86	41	0	0	14	16		
6– 9	50	19	38	156	7	5	65	17	36	46	16	32		
9–12	20	6	30	515	0	0	7	1	71	61	29	38		
Lake Opeongo														
6– 9	19	11	58	243			13	6	50	79	50	15		
9–12	47	13	28	423					91	97	15	3		
12–15	66	17	26	768			6	1	92	85	12	11	6	3
15–18	2	1							100	100				

From Lake Traverse, of the six specimens examined in the 9–12 inch class, four were empty and two contained crayfish. Of six in the 12–15 inch class, two were empty, one contained fish and a dragonfly nymph, one had eaten fish, one had taken fish and crayfish, and the sixth contained remains of tadpoles. In general, the food of bass in Lake Traverse is composed of fish and crayfish, with the addition of small quantities of insect nymphs and tadpoles.

Of the five bass taken from the Petawawa River, four were in the 9–12 inch class, and, of these, two contained insects, one had fish and insects, and one

insects in the food of young bass. Bass of intermediate size have been shown to feed on crayfish, fish, and a few insects, and the largest bass to feed on fish and small amounts of crayfish. The results of the present studies, insofar as the food of immature and adult bass is concerned, substantiate earlier findings for the most part, but have widened knowledge of variations in kinds and amounts of food consumed. For instance, the largest bass examined in two parts of the Great Lakes, Lake Erie and Georgian Bay, had fed mostly on fish, whereas bass of comparable size in inland waters such as Cache and Opeongo

had eaten crayfish. It was noted that bass of small, rocky lakes ate considerable numbers of insects, as did also those from streams.

In Georgian Bay and Lake Opeongo, where a higher percentage of smaller than of larger bass had empty stomachs it may be that the smaller immature bass ate less often than did the larger ones, but, since their diet embraced fewer crayfish with their hard chelae, it seems more probable that the rate of digestion was more rapid in the smaller, than in the larger fish.

The average amount of food found in the stomachs increased with the length of the bass, in Lake Erie, Lake Opeongo, Cache Lake, and Georgian Bay. An increase of three inches in length was associated with the consumption of from 1½ to more than 3 times as much food. That the food increases would be better associated with growth in weight has been considered, and the three-inch length increments can be regarded as indicating increases in weight of from 2.2 to 3.0 times. On the average, a doubling in weight is coincident with the presence of about 1½ times as much food in the stomach.

Some correlation between growth and the volume of the chief food item found in bass stomachs seems evident. Bass eat more in warmer water than in water near freezing. When the bass are listed in a series from those of fastest to those of slowest growth (Table 7), then the arithmetical products of: Amount of chief food item in stomachs × Number of frost-free days in the year (the growing season), also become arranged from highest to least. That is, better growth is correlated with a longer period of activity on the part of the fish, and a higher total intake of the chief food organism.

TABLE 7

DATA INDICATING A RELATION BETWEEN GROWTH OF SMALLMOUTH BASS AND THEIR FOOD

Lake	*Average total length at 4 years of age, inches*	*Volume of chief food item/100 stomachs in the 9–12" class, cc.*	*Approximate average length of frost-free period, days*	*Product, Food × Days*
Erie	12.3	290 (fish)	200	580
Opeongo	10.8	410 (crayfish)	100	410
Cache	10.0	314 (crayfish)	100	314
Georgian Bay	9.0	224 (fish)	134	300

NESTING

Nesting of the smallmouth bass, comprising: selection of the site, construction of the nest, deposition and fertilization of the eggs, and hatching and guarding of the young, has been investigated in even fewer waters than have growth and food of the bass. Some of the earliest written notes on the nesting of smallmouth bass in Ontario are those in the diary of John W. Kerr (1871), a federal fisheries department officer during the latter part of the last century. "Regarding the fit and proper close time for pickerel, pike, maskinonge, and bass," in the southern part of the province, he says:

"Take for instance bass—the close time for bass should be fixed from about

the 15th of May until the 20th day of June following. Bass make their bed in muddy and gravel bottoms of streams, and beaches, where the female and male deposit the spawn. Both parent fish remain by the bed to protect the eggs, and keep away other fish from devouring them, until the young hatch out, when the parent fish take them away, under their care and protection, and go away to places unknown to me. The spawn of bass is never found deposited amongst grass and rubbish brought up by the seines in hauling, because it is buried like that of the salmon a few inches beneath the surface of the bottom, and placed where the seine net hauling cannot disturb it. All the bass tribe, and even sunfish, spawn in the same way." We would now say that Kerr's observations that both parents serve as guards, and that the spawn is buried, are somewhat in error.

Kerr also wrote that in Mitchell's Bay, Lake St. Clair, fish spawn about a week earlier than do fish of a like kind in the neighborhood of Hamilton, at the western end of Lake Ontario. "This is accounted for in consequence of the season coming in earlier there than here (Hamilton), causing the water to change in its temperature, which ripens the fish earlier for spawning."

Bensley (1915) reported that spawning of bass in Georgian Bay generally occurred in June, but guarding of nests had been observed until July 20. The nest is described as being a shallow basin 15 or 20 inches in diameter, and having a weedy or pebbly bottom. Tester (1930) made a report on the spawning of smallmouth bass in Georgian Bay and Lake Nipissing. He found that nests were generally located in places sheltered from direct wind and wave action and protected from enemies by submerged rocks or fallen trees. At temperatures ranging from 54° to 73.5°F., and averaging 62°F., bass fry rose 12 days after hatching. Bass embryos, at a stage just previous to hatching, were killed when the temperature of the water rose as high as 73.5°F. In 1928, 1929, and 1930, nests were guarded by the male bass after the season for bass fishing opened (July 1), the guarding period in one instance lasting until July 20.

In Lake St. Clair, investigations were centered at Mitchell's Bay between June 11 and July 6, 1935, and a few observations were made in other parts of the lake. It was found that all localities providing between two and three feet of water, sand bottom, and a few reeds were suitable nesting areas. Some bass nests were built at distances up to one-half mile from shore, in situations unprotected from direct wave action. Nesting grounds constituted about 12 per cent of the total area of Mitchell's Bay. West from the Bay, along the north shore of the lake towards the international boundary, over a distance of 12 miles, there are also great areas suitable for bass nesting.

Detailed studies and measurements were made of 29 nests. A nest bottom was of clean sand, but sometimes lying in the depression were old *Eleocharis* stems, dead *Nitella*, and occasionally some clam shells. A rim of clean sand bordered the depression, and in turn was surrounded by the normal, sandy, "moss" (*Nitella*)-covered lake bottom. Living reeds served to outline and define the nest boundaries, but did not give substantial protection from wave

action or enemies. Mitchell's Bay is devoid of bottom cover such as rocks and logs, that so often shelter one side of a nest in some regions. The average nest depression was circular, with a diameter of 18 inches, and a central depth of 3½ inches from the level of the lake bottom; the surrounding rim was about one inch in height.

It was found, in two quite separate areas, that there were 25 nests in 440 square yards, and 76 nests in 1,476 square yards, or on the average one bass nest for 19 square yards of bottom. These two areas appeared to be favored, and it is probable that nests were not so numerous in other localities.

Bass nests were first observed on June 12. At that time the adult fish were guarding in the vicinity of the nest sites, generally maintaining a patrol around the nest within a distance of 50 feet, driving away any other smallmouth bass, rock bass (*Ambloplites rupestris*), perch, and sunfish (*Eupomotis gibbosus*) that appeared. At that time the young fish were about two-fifths of an inch in length. They were in a dense school above the nest, near the surface of the water, but were beginning to disperse. Inclement weather from June 17 to June 23 disrupted guarding activities. Before June 17, sentinel bass, none less than about 11 inches in length, were on duty; after June 23, when the water had cleared sufficiently to permit of observation, guarding had been concluded.

On June 12 it was estimated that there were about 2,000 fry in the immediate vicinity of an observation nest. By July 5 less than 25 young bass could be associated with the original school. The young spread out gradually from the nest, tending to follow existing lines of vegetation, and by the beginning of July occupied about 50 yards along the edge of a reed-bed. The fry remained in water less than three feet in depth. On calm, sunny days they ranged near the surface, but during windy and cloudy periods retired to the cover of the "moss" on the bottom.

Studies of nesting bass were continued at Mitchell's Bay from May 26 to June 18, 1936. Eleven nests were placed under intensive observation. The young had hatched previous to May 30, and those of nearly all the nests rose from the bottom uniformly on June 6. Lengths of guarding adults were from 11 to 16, averaging about 14, inches. Guarding was completed by June 20.

A census of nests was taken on presumably typical nesting ground. Within a measured and marked area, of 47 by 200 yards, there were 106 nests with young bass and 17 nests with no contents. The census was made on June 13, after all hatching was completed. There was on the average one nest per 75 square yards of bottom area, and about 14 per cent of the nests were unproductive. This compares favorably with the Pointe au Baril region of Georgian Bay where, in the same year, 36 per cent of the bass nests were failures.

In Georgian Bay, nesting of bass was observed at Pointe au Baril from June 20 to July 13, 1936. Measurements and observations of the physical characteristics and water relations of some nests were made. The average bass nest was 2½ feet from shore, circular, 14

inches in diameter, had a gravel bottom, was $1\frac{3}{4}$ inches in depth, surrounded by a rim $1\frac{1}{2}$ inches in height, had a nest depression of about 155 square inches, and was in 18 inches of water. These differed from those of Lake St. Clair in being closer to shore, in shallower water, of smaller diameter, of shallower depression, and in having a bottom of gravel and stones instead of sand. Large-sized bass did not always guard either large- or small-sized nests. Most nests were located in the lee of islands, where they were not exposed to high waves such as prevail on the western, windward side.

Out of 11 nests under observation, four were failures in that the eggs died or were destroyed by nesting rock bass. The failure of these four nests became evident between June 22 and June 26. At the remaining successful nests, guarding was concluded on dates between July 1 and sometime after July 13. The nests that failed were all guarded by 10 and 11-inch parents, while the guards of the successful nests were from 11 to 15 inches long. Sixty-four per cent of the guards were 10–11 inches in length and their nests were 43 per cent successful, and the remaining 36 per cent of the guards were 12 inches and over in length and their nests were 100 per cent successful.

Angling at the beginning of the open season often results in the capture, sometimes inadvertently, of male bass which have not yet completed guarding duties. If the opening of the bass season had been on July 10, 1936, 57 per cent of the successful guarding bass would have had protection, and a July 12 opening date would have saved 71 per cent. The regular opening date of July 1 offered no protection to these most desirable types of bass.

When the young were rising, and for a week after so doing, they appeared to have little or no sense of self-protection, but basked or feebly swam short distances. For about two weeks after rising the fry remained of a black color, easily visible in clear or slightly clouded water. At the end of this time their color gradually became lighter, took on a greenish tinge, and they were less easily seen. When the young had changed in color from black to greenish they adopted habits more characteristic of adults, such as hiding under rocks or vegetation and darting out upon their prey. As they became older their agility and adeptness at avoiding capture increased. It was general for guarding to become lax and finally terminate when the young assumed the greenish color.

CREEL CENSUS

A creel census is the means by which catches may be measured, and serves to give some idea of the drain on a fish population resulting from angling. The census measures the take not only as to sizes and numbers of fish, but also as to the time required to make the catch. It is probably true that waters containing an adequate food supply as well as bass that show good growth are also those from which more fish can be taken without seriously depleting the stock.

Following the method of Fry and Kennedy (1937), and continued by Fry (1939), in Algonquin Park, the creel census has been a reliable measure of the catch and an estimate of the fishing effort. In Lake Opeongo, a

census of bass caught by anglers in 1936 was taken in conjunction with the lake trout survey. Slightly more than 300 bass were reported for the season (Table 8), one-half of which were between 12 and 14 inches in length (legal minimum length, 10 inches), and the greater proportion of the season's catch was taken during August. The estimated total season's catch is placed at 1,000 bass with an average length of 13.8 inches, an average weight per fish captured of 29.5 ounces, and a yield of 0.13 pounds per surface acre.

The creel census was continued in Lake Opeongo in 1937 under the direction of Dr. Fry, who has generously supplied the data for that year. The number of bass reported was 628, representing an estimated 80 per cent of the total season's catch of 785 bass weighing 1,325 pounds. The average length was 13.5 inches, and the yield has been calculated at 0.098 pounds per acre of lake surface. Effort is defined as the number of hours required for two men in one boat, the usual fishing party, to catch their limit of 12 bass, when no

TABLE 8

CREEL CENSUS RETURNS FOR SMALLMOUTH BASS TAKEN BY ANGLERS IN LAKE OPEONGO IN 1936 AND 1937, AND IN CACHE LAKE IN 1937

Locality and date	Length in inches										Total, length known	Total, length unknown	Total recorded catch
	10	11	12	13	14	15	16	17	18	21			
Lake Opeongo, 1936													
July	1	6	18	20	10	8	2	3	1	1	70	28	98
Aug.	4	4	20	16	13	7	1		1		66	111	177
Sept.		3	4	5	7	3	4				26	1	27
Total	5	13	42	41	30	18	7	3	2	1	162	140	302
*%	3	8	26	25	19	11	4	2	1	1			
†%cum.	3	11	37	62	81	92	96	98	99	100			
Lake Opeongo, 1937 (after Fry)													
July	12	24	26	38	29	15	3		1		148	60	208
Aug.	12	19	29	30	36	17	6	1			150	93	243
Sept.		5	17	20	20	13	6		1		82	89	171
Oct.		1		1	3	1					6		6
Total	24	49	72	89	88	46	15	1	2		386	242	628
*%	6	13	19	23	23	12	4						
†%cum.	6	19	38	61	84	96	100	100	100				
Cache Lake, 1937													
July	69	43	37	13	4	4					170		
Aug.	14	5	6	8	4	2					39		
Sept.		2	1								3		
Total	83	50	44	21	8	6					212		
*%	39	24	21	10	4	3							
†%cum.	39	63	84	94	98	101							

*% Per cent of length-known catch.
†%cum. Cumulative percentage.

other fish were taken. It is a measure of the "catchability" of the fish. Bass were not easy to catch early in July, the effort being 10.2 hours, but were taken with less difficulty during the latter part of that month, and with least difficulty early in August (6.2 hours), and the difficulty of capture increased again towards the end of the summer. The average number of fish caught per 100 hours fishing varied from a maximum of 193 in early August to a minimum of 117 at the beginning of July.

In Cache Lake a creel census was conducted during the 1937 angling season (Doan, 1937). The fish reported comprised an estimated 80 per cent of the total season's catch of 403 bass, with a weight of 390 pounds. The yield of the lake was 0.58 pounds of bass per surface acre. Bass of 10 to 12 inches in length made up 83 per cent of the reported take, and the chances of catching a bass 15 inches in length were 1 in 36. The time effort for two men to take limit catches of six bass per man, using the still-fishing method, was 4.6 hours in July, and 4.1 hours in August.

It has been demonstrated in the cases of Lake Opeongo in 1936 and 1937, and in Cache Lake in 1937, that a creel census can be used as a means of determining just what numbers and sizes of smallmouth bass a body of water is producing. Lake Opeongo, a large lake with relatively little drain on its bass population, is an example of a water in which the bass are of large average size, apparently have access to a sufficient supply of food, and grow rapidly. It is believed that too great a proportion of the present bass population represents capital stock, that the yield is low, and that a greater sustained yield could be obtained by increasing the intensity of the fishing. There may be danger that the bass, of comparatively recent introduction to the lake, will become so numerous that their food supply will be depleted, and they in turn will undergo reduction in size, as has been the case in Cache Lake.

Cache Lake, a small lake subject to an intensive fishery, is an example of a body of water in which the bass are of a small average size, have available only a limited supply of food, and grow slowly. Popular opinion deplores the small size but not lack of abundance of the bass, of which there are considerable numbers. A reduction in the numbers of bass, together with attempts to restore the natural food supply, should help to build up a population of bass whose size, if not numbers, would prove more acceptable to anglers. However, there are some lakes that never can be expected to yield enough fish to satisfy the demand, and Cache Lake may well be one of them.

Discussion and Conclusions

The lakes and rivers from which smallmouth bass have been taken for these studies are so varied, and the bass themselves have exhibited such different characteristics of growth, food, and reproduction that further consideration of some of the inter-relating factors is warranted.

Classifying the lakes solely on gross features, they may be divided into large and small, northern and southern, and deep and shallow.

The growth of bass fry in all the waters studied has been quite uniform; on a given date, the diversity in size of fry from separate waters has not been

due to extensive differences in rate of growth, but to the length of time the fry had been growing. Although retardation in growth has been observed coincident with drops in water temperature, it is believed that the fry did not undergo extensive growth rate changes at any time during the investigations. As the fry grew into larger fish, it was noted that their growth became irregular. The growth of adult bass in different waters showed what is probably a net effect of adverse and favorable conditions over a number of years. Fingerlings from various waters varied in length by about one inch, immature bass had a length range of 1½ inches, but at 10 years of age the extremes differed by about three inches.

The types and amounts of food eaten by bass of different sizes have also been shown to vary. Generally speaking, small bass feed on plankton, insects, and small fish, and adults on crayfish and fish. However, there are some waters where the bass, in both immature and adult stages, have continued to feed on food regarded as being typically the food of smaller bass. For instance, in some lakes adult bass feed to a large extent on insects, due it is believed, to food shortage.

Feeding continues as long as the food supply and water temperature are favorable, or, until the fish has eaten all that its capacity will allow. It seems that the bass is characterized by a willingness to gorge whenever opportunity occurs; e.g., in captivity, a bass of 11¼ inches ate 105 minnows, of from 1–1½ inches, in less than an hour. Although appetite may be sufficient, opportunities for wild bass to achieve complete satiation may be few, especially in northern lakes. Good correlation between large amounts of food found in bass stomachs and rapid growth was noted.

Even if an abundance of food is available, bass will consume very little of it if the temperature of the water is low. Bass become active and commence active feeding when the water warms in spring, and feeding slackens when it cools again in autumn. If the summer season is short, or if the water is warm for only a short period, then bass will have opportunity for only a limited amount of feeding, and will grow slowly.

The nesting period of the smallmouth bass is governed by the temperature of the water. A longer growing season will be available to the young bass if the water in a given lake becomes warmer earlier in the year than in other lakes. The warming of the water is due to the sun, and a lake will become warmer more rapidly if it is shallow than if it is deep. Consequently, shallow lakes such as St. Clair and Nipissing offer earlier spawning conditions than do deeper and colder waters such as Georgian Bay, and in these shallow lakes there is a longer growing season. From temperature considerations alone, bass should make good growth in shallow waters. If the water of a lake, due to its northerly position or to the inflow of cold springs, does not become warm enough for spawning, then bass cannot become established. Introduced, however, individuals might persist and grow slowly for some time.

Introductions of bass into waters to which they are not native will result in disappointing returns if the water temperatures are so low as to inhibit feeding or spawning. However, quite different results, eventually disappointing

also, will result when bass are introduced into waters of small size, and of rocky or boggy nature without lasting food resources. The native fish fauna may provide an abundant source of food for a short time, and the bass will grow large, and even multiply, if favorable temperature and bottom conditions prevail. When the food supply has been reduced to a minimum, however, the younger generations of bass will make slower and slower growth, and eventually the lake will be populated entirely with bass of only small sizes.

The creel census offers a way of determining the drain of angling on a bass population. In conjunction with studies such as have been presented in this paper, it would be possible to use a creel census as an indicator of a population and a basis of control for a program of long-term management of the bass for sporting purposes. It is to be hoped that more coordinated work, along the lines of creel census and growth and food analyses of bass samples, will lead to satisfactory methods of evaluating the optimum annual yields of this fish from different waters.

Examples illustrating the generalizations made in preceding paragraphs are:

Large lakes
  Northern
    Deep
      Bass native, growth poor
        Georgian Bay
      Bass introduced, growth good (presumably for a limited number of years)
        Lake Opeongo
    Shallow
      Bass native, growth good
        Lake Nipissing
        Lake Traverse
  Southern
    Shallow
      Bass native, growth good
        Lake Erie
        Lake St. Clair
Small lakes
  Northern
    Deep
      Bass introduced, growth poor
        Cache Lake
        Meach Lake
    Shallow
      Bass introduced, growth poor
        Found Lake

Large, northern, deep lakes do not support a population of bass showing good growth, but such development may be made in those lakes by bass that have been present for a few years as an introduced species. Large, shallow lakes, both in the north and in the south, may maintain both numbers and good growth of bass.

Of the small bodies of water, the northern, deep lakes into which bass have been introduced are apparently unsuitable. Even shallow, northern lakes of small size, so far as is known, do not provide the requirements for balanced bass populations. In general, small lakes do not support an ecological community in which the smallmouth bass will thrive for any considerable length of time.

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STUDIES ON A POPULATION CYCLE OF SNOWSHOE HARES ON THE LAKE ALEXANDER AREA

II. MORTALITY ACCORDING TO AGE GROUPS AND SEASONS[1]

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In the first paper of this series (Green and Evans, 1940) we presented a description of the procedures used and the results obtained in the annual censuses of snowshoe hares on the Lake Alexander Area, in Morrison County, Minnesota, during a period of eight years. These studies, carried out on an area six and one-half square miles in extent, showed a decline in population from a maximum of about 500 hares to the square mile in February 1933 to a minimum of about 32 hares to the square mile in 1938. In the present paper, further details concerning the mortality rates among snowshoe hares, with especial reference to age groupings, are recorded.

Age Ratios of Hares on the Lake Alexander Area, 1934–39

During the past seven years, about 5,000 hares have been trapped on the Lake Alexander Area. Some have been taken 15 or 20 times over a period of several years. A hare trapped in a given station was usually found in the same station or in an adjoining one, if trapped later, even though several years had elapsed. From extensive experience, we have learned that snowshoe hares live in a markedly restricted range. This fact makes it practicable, by analysis of the accumulated trapping records, to determine the age groupings of hares each year, and also to estimate the annual mortality in the various age groups.

In order to determine age ratios, it is desirable to have as a basis for calculations, a representative sample of hares taken within a comparatively short time from all parts of the area. Hares trapped during the census period constitute such a sample. In 1934, 1935, and 1936, the number of hares trapped in the census period was sufficiently large to form an adequate basis for the calculation of age groupings. However, the population of snowshoe hares was so drastically reduced in 1937 that in order to obtain records of a sufficient number of hares to make the calculations reliable, it was necessary to include animals trapped from about the middle of February to the end of the trapping season in May. All stations on the area were trapped twice between February 12 and May 11, 1937, once in the latter part of the precensus period and once during the census period (Green and Evans, 1940). By including the animals trapped in this extended period of about three months, we obtained a sample of 209 hares, or about 25 per cent of the total population.

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A further decrease in the population made it impossible to trap in 1937–38 and in 1938–39 samples of hares large enough to permit analyses as detailed as those carried out in earlier years. However, by including all hares trapped in the entire season, a satisfactory approximation of the proportion of yearling hares in the population during those two years was obtained. The data on age ratios for 1938–39 are based on hares trapped on the Mile Area, only, as precensus trapping was limited to that part of the area.

The principle on which the age groupings are calculated is fundamentally that used in determining the annual population and can best be explained by an example. In the census period from April 12–28, 1934, 329 hares were caught. Of these, 58 had been banded the previous season, 1932–33, and therefore must have been born in 1932 or before. Obviously other hares in the group of 329 were equally old but had not been marked in 1932–33. Our records show that 1,184 hares were tagged in the 1932–33 season. As the estimated population was 2,390, there were about 1,206 additional hares present on the area at that time (hares that were not banded or had been banded prior to the season of 1932–33). It follows that if we multiply 58 by the factor 1,184/1,206, we obtain the number of additional hares in the 329 that were of the same age group as the 58; that is, if X = the number of additional hares, in the 329, of the same age group as the 58 (hares two or more years old), then $58:X = 1{,}184:1{,}206$.

$X = 59$, the number of additional hares, in the 329, of the same age group as the 58 banded in 1932–33

By adding 58 to 59, we obtain 117 as the number of hares, in the 329, that were born in 1932 or before.

Summary:

329 hares were trapped April 12–28, 1934

117, or 35.6 per cent were born in 1932 or before (hares two or more years old)

212, or 64.4 per cent, were born in 1933 (yearlings)

TABLE 1

TRAPPING DATA ON WHICH DETERMINATIONS OF AGE RATIOS ARE BASED

Trapping periods	Distribution of hares trapped, according to years in which they were banded							Total number of hares trapped
	1932–33	1933–34	1934–35	1935–36	1936–37	1937–38	1938–39	
Apr. 12–28, 1934	58	271						329
Apr. 12–29, 1935	16	48	208					272
Apr. 23–May 10, 1936	3	9	22	77				111
Feb. 12–May 11, 1937	2	11	16	22	158			209
Nov. 1, 1937–Apr. 20, 1938		1	1	2	1	59		64
Nov. 1, 1938–Apr. 24, 1939*			1	1	1	11	68	82

* Figures for 1938–39 apply to the Mile Area only.

TABLE 2

NUMBERS OF BANDED AND UNBANDED HARES ON THE LAKE ALEXANDER AREA

Year	1933–38		
	Calculated population	Number of hares banded	Number of hares not banded
1932–33	2,390	1,184	1,206
1933–34	1,871	989	882
1934–35	1,707	761	946
1935–36	1,180	220	960
1936–37	Figures for 1936–37 not used in determination of age ratios		
1937–38*	66	47	19

* Figures for 1937–38 apply to the Mile Area only.

From this example, it may be seen that the following information is necessary to determine the age grouping of hares: (1) the total number of hares trapped in the time for which the age ratio is to be determined, usually the census period; (2) the number of these hares that were banded in each of the preceding years; and (3) the ratio of banded to unbanded hares in the population as a whole in each of those years. The data for the years 1932–33 through 1938–39 are presented in Tables 1 and 2.

As another example, let us consider the method used in determining age ratios as applied to the data for 1935. In the census period, April 12–29, 1935, 272 hares were caught. Of these, 16 had been banded in the season of 1932–33 and 48 in the season of 1933–34.

First we determine the number of hares born in 1932 or before:

Let X = the number of additional hares, in the 272, of the same age group as the 16 (hares three or more years old)

$$\frac{16}{X} = \frac{1,184^*}{1,206}$$

* Derivation of ratio explained above.

$X = 16$, the number of additional hares, in the 272, of the same age group as the 16 banded in 1932–33

$16 + 16 = 32$, the number of hares born in 1932 or before

Next we determine the number of hares born in 1933 or before:

Let X = the number of additional hares, in the 272, of the same age group as the 48 that were banded in the season of 1933–34 (born in 1933 or before). In the season of 1933–34 (see Table 2), 989 hares were banded; and, according to calculations, there were on the area 882 hares not banded or banded prior to the season of 1933–34 (population = 1,871).

$$\frac{48}{X} = \frac{989}{882}$$

$X = 43$, the number of additional hares of the same age group

$48 + 43 = 91$, the number of hares born in 1933 or before

Because some of the hares banded in 1933–34 must have been two, three, or four years old and would be included in the group of "hares born in 1932 or before," the group of 91 includes the 32

referred to above. Consequently, we subtract 32 from 91 to find the number of hares born in 1933.

91 − 32 = 59, the number of hares born in 1933

The number of hares born in 1934 is determined by subtracting from the total number trapped the number born in 1933 or before:

272 − 91 = 181, the number of hares born in 1934

Summary:

272 hares were trapped April 12–29, 1935

32, or 11.8 per cent, were born in 1932 or before (hares three or more years old)

59, or 21.7 per cent, were born in 1933 (hares two years old)

181, or 66.5 per cent, were born in 1934 (yearlings)

Age ratios similarly calculated for 1936 from the data given in Tables 1 and 2 indicated that in April of that year 56 per cent of the snowshoe hares on the Lake Alexander Area were yearlings, 29 per cent were two years old, 10 per cent were three years old, and 5 per cent were four or more years old. As already mentioned, an insufficient number of hares were trapped in the census period of 1937 to constitute an adequate basis for determinations of age ratio. By combining the data from the latter half of the precensus period with that from the census period, we included 209 hares, or about 25 per cent of the entire population, in our calculations. The results shown in Tables 3 and 4 indicate that yearlings constituted only 44 per cent of the population, with the remainder divided as follows: 39 per cent, two years old; 7 per cent, three; 8 per cent, four; and 2 per cent, five years old.

As a result of the further decline in the hare population, only 64 animals were caught in the entire trapping season of 1937–38. Although this number is too small to permit measurement of the number of hares in each age group, it is large enough to allow an estimate of the proportion of yearlings in the population. Only five of the 64 hares had been banded in previous years: one in 1933–34, one in 1934–35, two in 1935–36, and one in 1936–37. If we assume that in the group of 64 there were

TABLE 3

CALCULATED AGE GROUPING OF HARES

Trapping periods	Calculated distribution of hares trapped, according to date of birth								Total number of hares trapped
	1932 or before	1933	1934	1935	1936	1937	1938	1939	
Apr. 12–28, 1934	117	212							329
Apr. 12–29, 1935	32	59	181						272
Apr. 23–May 10, 1936	6	11	32	62					111
Feb. 12–May 11, 1937	4	17	15	82	91				209
Nov. 1, 1937–Apr. 20, 1938				10		54			64
Nov. 1, 1938–Apr. 24, 1939*				15				67	82

* Figures for 1938–39 apply to the Mile Area only.

TABLE 4

AGE RATIOS OF HARES IN SIX CONSECUTIVE YEARS

Year	*Percentage of yearling hares*	*Percentage of hares 2 yrs. old*	*Percentage of hares 3 yrs. old*	*Percentage of hares 4 yrs. old*	*Percentage of hares 5 yrs. old*
1934	64	36 (2 yrs. or older)			
1935	66	22	12 (3 yrs. or older)		
1936	56	29	10	5 (4 yrs. or older)	
1937	44	39	7	8	2 (5 yrs. or older)
1938	85	15 (2 yrs. or older)			
1939	82	18 (2 yrs. or older)			

five additional hares of the same age as the five old-banded animals, a reasonable estimate in view of data already presented, we are led to the approximation of 54 yearlings and 10 older hares. In other words, about 85 per cent of the hares trapped in 1937–38 were yearlings, and 15 per cent were two or more years old.

In the trapping season of 1938–39, 82 hares were captured on the Mile Area. Eleven of them had been banded in the 1937–38 season, and one in each of the preceding three years. The remaining 68 were banded for the first time during 1938–39. On a basis of the 11 banded in 1937–38, we calculated the number of hares two or more years old and found that they constituted 18 per cent of the entire group. Only hares trapped on the Mile Area were included in these calculations, because trapping during the precensus period of the previous year, 1937–38, was confined to the Mile Area.

A summary of the results for each of the six years for which age groupings have been calculated is given numerically in Table 3 and in terms of percentage in Table 4.

SIGNIFICANCE OF DATA ON AGE RATIOS IN REGARD TO POPULATION CYCLES

Although the figures in Tables 3 and 4 are not mathematically precise representations of the actual age grouping of hares, they may be regarded as satisfactory approximations and undoubtedly indicate certain significant facts. In the years 1934, 1935, and 1936, yearling hares constituted about 60 per cent of the entire population. The period covered by these figures extends from the time of maximum hare population well into the period of decline. Shock disease took a heavy toll during the winter and early spring months of 1935 and 1936, yet the proportion of yearling hares in April 1936 was only moderately smaller than that in April 1934, when the disease was at a minimum.

In 1937, the proportion of yearlings in the snowshoe hare population was about three-fourths that of previous years. The total population of hares on the Area decreased from 246 to the square mile in 1936 to 151 in 1937. Further analysis of data for these years, to be presented later in this paper, reveals that of the hares on the Area in

February 1936, about 65 per cent died during the following year, a mortality no greater than that during the preceding years of our study. Consequently, the decline in population from 246 hares to the square miles in 1936 to 151 in 1937 may be attributed almost entirely to a decreased number of yearling hares.

Although our calculations for 1938 are based on only 64 hares, there can be little doubt that the proportion of yearling hares was markedly greater than in 1937. However, the increase in the proportion of yearlings in the population from 44 per cent in 1937 to 84 per cent in 1938 coincided with a pronounced decline in actual number of yearlings on the area because the total population during this interval was reduced from 150 to 32 hares to the square mile. The full significance of the reduced number of yearling hares in years when the population was steadily decreasing cannot be evaluated until data on the reproduction of hares are presented. In the third paper of this series, we shall show that with the aid of the data on the numbers of yearling hares each year, it is possible to estimate the mortality among young hares from the time of their birth to the following February and that variations in the rate of mortality from year to year constitute a major factor in the cyclic fluctuation in populations of snowshoe hares.

In the trapping season of 1938–39, general observations, as well as census calculations, indicated that the period of decline had ceased and that the number of hares on the area had increased to approximately twice that of the previous year. Concurrently with this rise in the total population, an increase in actual number of yearlings, as well as in the poportion of the population that they constituted, became well defined. According to our data, 80 per cent or more of the hares on the Lake Alexander Area were yearlings in the winter of 1938–39.

Age Ratios Early and Late in the Trapping Season

In the first paper of this series we described a mortality of about 43 per cent among hares on the Mile Area in a period of approximately 10 weeks during the winter of 1935–36. In order to determine whether the winter mortality occurred principally in young hares, in old hares, or equally in both, the age ratios of hares on the Mile Area early and late in the trapping season have been determined for the year 1935–36.

Between November 23, 1935, and January 15, 1936, 166 hares were trapped on the Mile Area. Ninety-seven of these had not been previously trapped. The remaining 69 had been banded as follows: six in the 1932–33 season; 23 in the 1933–34 season; and 40 in the 1934–35 season. Age ratios were determined by the method used in calculating the age ratio in April 1936.

Between March 1 and April 9, 1936, 132 hares were trapped on the Mile Area. Forty-nine of this group had been banded prior to the current trapping season: three in the 1932–33 season; 15 in the 1933–34 season; and 31 in the 1934–35 season. The age ratios of these hares likewise were determined and are shown in Table 5.

It is seen from Table 5 that the mortality in the winter of 1935–36 was practically the same in yearlings and older hares. Inasmuch as shock disease

TABLE 5

AGE RATIOS EARLY AND LATE IN THE WINTER OF 1935–36 ON THE MILE AREA

Date	*Percentage of yearling hares*	*Percentage of hares 2 years old*	*Percentage of hares 3 years old*	*Percentage of hares 4 or more years old*
Dec. 20, 1935*	57	22	14	8
Mar. 20, 1936*	54	29	12	5

* Approximate middle of the trapping period.

was rampant at that time, we may infer that during the winter this disease affects all age groups equally. Perhaps it would be more accurate to say that yearling hares have reached maturity by late autumn and accordingly suffer about the same mortality during the winter as do the older hares whether from shock disease or other causes.

SURVIVAL OF SNOWSHOE HARES

From the data on the age ratio of hares each year, we may calculate the annual mortality of hares in the various age groups. We can determine, for example, what proportion of the snowshoe hares present on the Area in a given year were alive one year later or three years later. Data and calculations relative to the annual mortality and survival of hares are presented in Tables 6 and 7.

In Table 6 all information on the survival of snowshoe hares is included in Columns III and IV and is calculated from the data in Columns I and II. In Column III the results are presented in terms of numbers of snowshoe hares on the Lake Alexander Area, and in Column IV the same data are expressed in percentages. Division A concerns only hares present on the Area in February 1933 and the number surviving in each subsequent year; Division B deals exclusively with survival of hares born in the summer of 1933 (yearlings in February 1934); Division C refers to the survival of hares born in 1934

TABLE 6

SURVIVAL OF SNOWSHOE HARES, 1933–37

	I		II		III	IV			
	Year	Total population	×	Percentage* in age group	= Number of hares in age group	Survival of snowshoe hares (based on Column III)			
						1933	1934	1935	1936
A	1933	2,390	×	100.0	= 2,390 hares in original population in Feb. 1933	100.0%			
	1934	1,871	×	35.6	= 666 hares 2 or more yrs. old in Feb. 1934	27.9%	100.0%		
	1935	1,707	×	11.8	= 201 hares 3 or more yrs. old in Feb. 1935	8.4%	30.2%	100.0%	
	1936	1,180	×	5.4	= 64 hares 4 or more yrs. old in Feb. 1936	2.7%	9.6%	31.8%	100.0%
	1937	756	×	1.9	= 14 hares 5 or more yrs. old in Feb. 1937	0.6%	2.1%	7.0%	21.9%
B	1934	1,871	×	64.4	= 1,205 yearlings in Feb. 1934		100.0%		
	1935	1,707	×	21.7	= 370 hares 2 yrs. old in Feb. 1935		30.7%	100.0%	
	1936	1,180	×	9.9	= 117 hares 3 yrs. old in Feb. 1936		9.7%	31.6%	100.0%
	1937	756	×	8.1	= 61 hares 4 yrs. old in Feb. 1937		5.1%	16.5%	52.1%
C	1935	1,707	×	66.5	= 1,135 yearlings in Feb. 1935			100.0%	
	1936	1,180	×	28.8	= 340 hares 2 yrs. old in Feb. 1936			30.0%	100.0%
	1937	756	×	7.2	= 54 hares 3 yrs. old in Feb. 1937			4.8%	15.9%
D	1936	1,180	×	55.9	= 660 yearlings in Feb. 1936				100.0%
	1937	756	×	39.2	= 296 hares 2 yrs. old in Feb. 1937				44.8%

* From Table 4.
The extent of the area on which the population was taken varied from 4.8 to 5.0 square miles.

(yearlings in February 1935); and Division D deals similarly with hares born in 1935.

In order to clarify the arrangement of Table 6, let us ask the question, "Of the rabbits born in the spring of 1933, how many remained one, two, and three years later?" In Division B, we see that in 1934 the total population was 1,871 hares, and that of these (reading to the right), 64.4 per cent, or 1,205 hares, were yearlings. In Column IV, we find that the 1,205 hares are considered 100 per cent. The second line in Division B shows that in 1935 there were 1,707 hares on the Lake Alexander Area, and that 21.7 per cent, or 370 of them, were two years old. In Column IV, we see that these 370 constitute 30.7 per cent of the yearlings of the previous year. Similarly, the next line shows that the total population in 1936 was 1,180 and that 9.9 per cent, or 117 hares, were three years old at that time. These 117 hares are 9.7 per cent of the 1,205 yearlings present in 1934, or 31.6 per cent of the two-year-old hares alive in 1935. The last line in Division B shows that the total population in 1937 was 756. Of this population, 8.1 per cent, or 61 hares, were four years old. Continuing to the right, we find that the 61 surviving hares represent 5.1 per cent of the original 1,205 yearlings, or 16.5 per cent of the two-year-old hares alive in February 1935, or 52.1 per cent of the three-year-old hares alive in February 1936.

In Column IV, one notes the frequent occurrence of figures close to 30 that represent the percentage of survivors after one year in various groups of hares. From the first year of our study through 1936, all age groups, without exception, showed a yearly survival of 30 per cent (+ or −2 per cent). Of the 2,390 hares on the Lake Alexander Area in 1933, 666, or *28 per cent*, remained in 1934. Of the 666, 201, or *30 per cent*, remained one year later. During the next year, the number was reduced to 64, or *32 per cent* of those present the previous year. Finally, from February 1936 to February 1937, the number of survivors was reduced to 14, or 22 per cent of the 64. In three successive years, therefore, the annual mortality ranged from 68 to 72 per cent, and in the fourth year, it was 78 per cent.

Let us consider again the hares born in the spring and summer of 1933. There were 1,205 yearling hares on the Lake Alexander Area in 1934. One year later their number had been reduced to 370, or *31 per cent* of the original group. In the course of the next year, the number was reduced to 117, or *32 per cent* of those present one year earlier. Again we note a mortality of about 70 per cent from 1934 to 1935* and from 1935 to 1936. Similarly, the hares born in 1934 were reduced from 1,135 in February 1935 to 340, or *30 per cent* of the original group one year later. The relatively constant annual mortality rate among adult hares of various ages is indicated by the figures for 1933, 1934, 1935, and 1936 (Table 6).

Although the survival of hares from 1936 to 1937 ranged, according to our calculations, from 16 per cent to 52 per cent in the different age groups, the irregularities may have been due to errors of random sampling. By considering all

* Population figures here, as elsewhere in this series of papers, apply to February of each year unless a specific statement to the contrary is made.

hares present on the area at the time of the census in 1936 as one group and calculating the mortality during the following year, we find that *36 per cent* of the hares survived (see Table 7), essentially the same proportion as in previous years.

It is particularly interesting to note that the mortalities from 1935 to 1936, and from 1936 to 1937 were practically the same as those in previous years, that is, about 70 per cent. As already mentioned, data and computations reported in the first paper of this series indicated a mortality of about 45 per cent in a period of ten weeks in each of two successive winters, 1935–36 and 1936–37. If these figures are even approximately correct, we must conclude that by far the greatest mortality among adult snowshoe hares occurs during the winter months. On the other hand, data to be presented in the third paper of this series show clearly that among young hares the largest mortality occurs during the summer months, probably during the first few weeks of their life.

The mortality during the following year, 1937 to 1938, appears to have been relatively greater than in any other year of our study, for, as shown in Table 7, only 3.4 per cent of the hares present on the area at the beginning of this period survived one year later. The exact significance of these data is not clear. Errors of random sampling may have had a considerable influence on the result. However, taken at their face value, these figures indicate a mortality only 50 per cent higher than that of previous years; i.e., an increase from the usual annual mortality of 65 or 70 per cent to 97 per cent. As the population of hares on the area was very small at this time, the higher death rate represents relatively few animals. The difference between a 70 per cent and a 97 per cent mortality, in this case, amounts to only 200 hares on the entire area during the year, or about three hares to the square mile each month. Resident predators might well account for the disappearance of this number of hares each month; but this suggestion is not entirely satisfactory, because it does not explain the difference between the mortality of the year 1937 to 1938 and that of the year 1938 to 1939 (as measured from the populations in February).

From 1938 to 1939, the death rate appears to have returned to approximately its former level. In fact, the figure of 41 per cent for survivors from

TABLE 7

ANNUAL SURVIVAL OF SNOWSHOE HARES, 1936–39

	Year	I *Total population*		II *Percentage* in age group*		III *Number of hares in age group*	IV *Survival of snowshoe hares (based on Column III)*
A	1936	1,180	×	100.0	=	1,180 hares, total population in Feb. 1936	100.0%
	1937	756	×	56.0	=	423 hares 2 or more yrs. old in Feb. 1937	36.0%
B	1937	756	×	100.0	=	756 hares, total population in Feb. 1937	100.0%
	1938	160	×	16.0	=	26 hares 2 or more yrs. old in Feb. 1938	3.4%
C	1938	160	×	100.0	=	160 hares, total population in Feb. 1938	100.0%
	1939	364	×	18.0	=	66 hares 2 or more yrs. old in Feb. 1939	41.0%

* From Table 4.

1938 in 1939 is higher, although perhaps not significantly so, than the corresponding figure in any other year of the investigation.

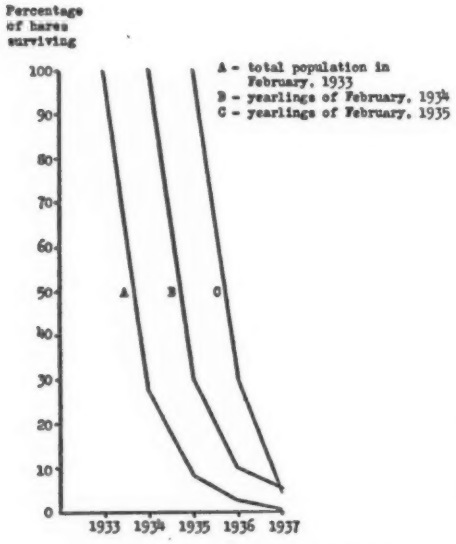

Fig. 1. Percentage of hares surviving in different cohorts, 1933–1937, inclusive.

The uniformity of the mortality rate in various age groups during the early years of the study is shown graphically in Figures 1 and 2. In Figure 1, curves A, B, and C, representing the survival of the total population of 1933 and of two succeeding crops of yearlings, are essentially parallel through 1936, but show deviations after that time. Similarly, the curves in Figure 2, based on the logarithms of the number of surviving hares (Column III, Divisions A, B and C, of Table 6) reveal parallel straight-line relationships through 1936 but show deviations in 1937 from the constant mortality of the preceding years. The remarkable uniformity of mortality among hares in various age groups in the years 1933, 1934, 1935, and 1936 indicates that neither the youthful agility of the yearlings nor the increased experience of older hares enabled either of these age groups to escape death more consistently than the other.

"Error of Random Sampling" in Determinations of Age Ratios

In the preceding pages, data on determinations of age ratios and yearly mortalities of various age groups have been presented at their face value without regard to possible errors of random sampling. In order to indicate the magnitude of the error that may have occurred because of this factor in some of the results presented, we have calculated for each year the standard deviation of the ratio of hares banded in the preceding year; i.e., the ratio on the basis of which the proportion of hares "two or more years old" is determined

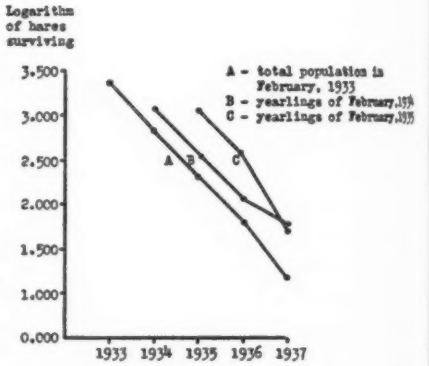

Fig. 2. Survival of hares in different cohorts. Note straight-line logarithmic decline in all three groups from 1933 through 1936.

(see Table 8). Using twice the standard deviation on either side of the observed figure, we have calculated the resultant range in which the percentage of hares two or more years old would fall. From

TABLE 8

ERROR OF RANDOM SAMPLING IN DETERMINATION OF "HARES TWO OR MORE YEARS OLD"

Year	N	P	p	σ_p	$2\sigma_p N$	$P \pm 2\sigma_p N$	*Proportion of hares two or more years old if P is actually $P \pm 2\sigma_p N$*
1934	329	58	$\frac{58}{329} = .176$	.0210	13.818	72	$72 \times \frac{1,206}{1,184} = 73$; $\frac{73+72}{329} = .44$
						44	$44 \times \frac{1,206}{1,184} = 45$; $\frac{45+44}{329} = .27$
1935	272	48	$\frac{48}{272} = .176$	.0231	12.5664	61	$61 \times \frac{882}{989} = 54$; $\frac{54+61}{272} = .42$
						35	$35 \times \frac{882}{989} = 31$; $\frac{31+35}{272} = .24$
1936	111	22	$\frac{22}{111} = .198$	.0378	8.3916	30	$30 \times \frac{946}{761} = 37$; $\frac{37+30}{111} = .60$
						14	$14 \times \frac{946}{761} = 17$; $\frac{17+14}{111} = .28$
1937	209	22	$\frac{22}{209} = .105$	.0212	8.8616	31	$31 \times \frac{960}{220} = 135$; $\frac{135+31}{209} = .79$
						13	$13 \times \frac{960}{220} = 57$; $\frac{57+13}{209} = .33$
1938	64	5*	$\frac{5}{64} = .078$	.0335	4.288	9	$9 + 9\dagger = 18$; $\frac{18}{64} = .28$
						1	$1 + 1\dagger = 2$; $\frac{2}{64} = .03$
1939	82	11	$\frac{11}{82} = .134$	.0376	6.1664	17	$17 \times \frac{19}{47} = 7$; $\frac{7+17}{82} = .29$
						5	$5 \times \frac{19}{47} = 2$; $\frac{2+5}{82} = .09$

Legend: N = Number of hares used in determination of age ratio
P = Number of hares banded in the preceding year

$$p = \frac{P}{N}; \quad p+q=1; \quad \sigma_p = \sqrt{\frac{pq}{N}} = \text{standard deviation of } p$$

* Total number of old-banded hares

† Calculations based on estimate that number of old unbanded hares equals the number of old-banded hares.

the statistical concept of standard deviation, it is apparent that the probability is only one in twenty that the actual number of hares is that indicated by the figure at either extreme of the range. The large size of the samples on which the ratios were determined, in comparison with the total population of hares, is conducive to greater accuracy than is indicated by the standard deviation. The validity of this statement is substantiated by the mortality figures already presented. The notably constant annual mortality of 70 per cent (+ or −2 per cent) in six distinct age groups of hares cannot be considered mere coincidence, but rather suggests an accuracy of the determinations of age

ratio and of our population studies even greater than would appear to be the case if the error of random sampling, as shown by the standard deviation, were fully operative. There can be no doubt, however, that the accuracy of figures presented for different age groups varies in a general way with that indicated by the calculated error of random sampling. We believe that the proportions of yearling hares shown by our data are sufficiently reliable to demonstrate the relative mortality among young and old hares on the Lake Alexander Area during the years included in this investigation.

SUMMARY

1. Data concerning the age ratios of hares each year from 1934 through 1939 have been presented. Calculations indicate that yearlings constituted about 60 per cent of the total population during the first three years. Later, the proportion of yearlings was markedly reduced concurrently with the increase in severity of the "die-off." In 1937, only 44 per cent of the hares were yearlings. In February 1938 about 80 per cent were yearlings; but inasmuch as the total population had been greatly reduced, this relatively high figure represents an actual decrease in number of young hares as compared with the number the previous year. In 1939, when the population was about double that of the preceding year, yearlings again constituted about 80 per cent of the total population of hares.

2. Age ratios were shown to be essentially the same on December 20, 1935, as on March 20, 1936, although there was a mortality of more than 45 per cent among the hares on the area during the interim.

3. From the determination of age ratios and the annual census of hares, it has been possible to calculate the annual mortality (from February to February) among hares of various age groups. The results indicate that the annual mortality among adults, whether yearlings or older hares, was maintained at a constant level of about 70 per cent throughout the years studied. The one exception, a mortality of 97 per cent from February 1937 to February 1938, has been discussed.

4. The significance of the data pertaining to age ratios and annual mortalities will be discussed more fully in the third paper of this series, after studies on the reproduction of hares have been reported.

CONCLUSIONS

1. On the Lake Alexander Area, the proportion and the absolute number of yearling hares were markedly lowered during the years when the population was most drastically reduced, and rose sharply when the population began to increase.

2. The mortality among adult hares was maintained at a relatively constant rate, irrespective of the cyclic changes in population measured by the annual census.

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NOTES ON NESTING AND OTHER HABITS OF THE WESTERN WHITE-WINGED DOVE IN ARIZONA

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The western white-winged dove (*Melopelia asiatica mearnsi*), interesting bird of the southwestern deserts, holds an important place among the game species of Arizona. Ranging throughout southern Arizona, northward to an irregular line from the New Mexican border near Safford westward through the southern part of the mountains to the vicinity of Stoneman Lake, Payson, Prescott, and Needles, the white-wing is found most abundantly in the valleys of the Colorado and Gila rivers, and of the tributaries of the latter, the Salt, Verde, Hassayampa, Santz Cruz, and San Pedro.

The great mesquite thickets of the river bottom-lands were, and still are, the centers of summer population though the acreage of these growths is annually reduced through reclamation for agricultural use. However, white-wings may be seen almost anywhere: in the desert on ironwood or giant cactus, or flying overhead; in the valleys of the desert mountains; even in the shade and fruit trees of the more highly developed agricultural areas; along country roadsides; and in suburban residential sections.

Ornithological literature contains little information on the life history of this dove. Notes concerning nesting may be found in each of the following works included in the list of Literature Cited: Bendire (1892), Gilman (1911), Swarth (1920), and Bent (1932). Most frequently quoted, however, will be Wetmore (1920), whose report covered studies made for the U. S. Biological Survey in 1919.

In June, 1938, the writer was assigned by the Survey to make studies of the life history of the bird to provide a satisfactory basis for its management as a game species. In a previous article in THE JOURNAL OF WILDLIFE MANAGEMENT (Neff, 1940) observations of the 1938 and 1939 seasons on range, distribution, summer populations, and shooting practices were discussed. The present progress report summarizes the data acquired relative to nesting, development of the young, and some phases of behavior.

In 1937, it was reported, white-wings were extremely abundant in the Phoenix district, nesting commonly even in residential sections of Phoenix and near-by smaller cities. Field work during 1938 was centered about Phoenix, covering an area extending to Wickenburg on the north, Florence on the east, and Coolidge and Gila Bend on the south. The gathering of extensive data on nesting was the major objective and nearly a month was spent in active search for, and study of, white-wing nests. In 1939 conditions were unfavorable and white-wings were sparsely scattered; nest studies were therefore minimized and attention was directed to other activities of the birds.

Upon arrival in Phoenix on June 22, 1938, interviews with officials and sportsmen brought forth the almost unanimous opinion that there was not more than one bird present in 1938

where there had been twenty in 1937. During the first week in the field the search for nests in sufficient number to permit satisfactory study was of most importance, and with U. S. Game Management Agent Lawhorn and Deputy State Game Warden R. L. Neill as guides and joint searchers the hunt progressed.

Moderate numbers of feeding white-wings were found at several points near Phoenix but inspection of every tree and cactus in section after section of the desert revealed only four scattered nests. At the end of the first week, a small nesting colony was located in the tamarisk jungle in the Gila River bottoms at Sacaton, and a large colony was found a few days later in the mesquite thicket near the mouth of the Santa Cruz River southeast of Laveen. In these two areas the nest studies of 1938 and 1939 were principally made; note was taken also of individual nests located here and there in the desert.

In addition, in 1939 Carlos Stannard studied white-wings nesting on his ranch northeast of Phoenix and Chas. P. Beach, chairman of the Arizona Game and Fish Commission made observations on his ranch south of Vail, Pima County. Both graciously made their data available to the writer.

MANNER OF NESTING

Besides nesting locally and individually, the white-wing has the interesting habit also of gathering into colonies of moderate to large size. From the few records available it appears that formerly they nested in numerous large communities in dense river-bottom thickets. Wetmore's work in 1919 was largely confined to two such colonies along the Gila River near Arlington. Superintendent A. E. Robinson of the Gila River Indian Reservation described a nesting of considerable size in mesquite near the reservation headquarters at Sacaton; after breeding in the same area for a number of years this band disappeared within the space of two years, and has not reappeared since 1927. Sportsmen described other colonies of similar history.

During the last two seasons, every effort was made to locate nesting aggregations; game wardens and sportsmen cooperated and many miles of favorable cover were inspected. Yet only the two colonies mentioned were located. A former resident of Arlington stated that the great assemblages in that area dwindled in a few seasons, between 1919 and 1925; thus it has been with many of those formerly known. Doubtless more than two have been in recent use, as not all would be easy to find in the countless thousands of acres of favorable nesting area that can be explored only on foot; yet as the search progressed one was constantly reminded of the nearly-unanimous opinion of Arizona's deputy game wardens that the white-wings have been decreasing every year.

DESCRIPTION OF COLONIES

The nesting colony at Sacaton was situated in a very dense growth of tamarisk (*Tamarix gallica*) in the Gila River bottom about a mile from the headquarters office of the Indian reservation. The growth throughout the thicket was dense, tall, and willowy, making climbing all but impossible; in places it was penetrable only by crawl-

ing underneath. Forcing through violently, disturbed the nesting birds and due to that reason and to the great effort required, only four day's observations were made here. The thicket was estimated as about 300 acres in extent, and the population of birds at not to exceed 500 pairs. In this report it is hereafter referred to as the Sacaton colony.

Near the mouth of the Santa Cruz river southeast of Laveen is a great alluvial flat with intermittent heavy growths of mesquite that is called by the local Pima Indians the New York thicket. In some places it is said to be fully six miles in diameter. Nowhere is the growth continuous, however, mesquite thickets covering several acres being interspersed with openings of similar size. The thickets are connected by strands of mesquite growing along the banks of the numerous washes that meander in from the south. At the margins of the big thicket the growth of mesquite is young and short, but in older sections the mesquite (*Prosopis chilensis*) and screwbean (*Strombocarpa pubescens*) reach heights up to about 40 feet. The entire thicket is on the Gila River Indian Reservation, a few miles east of the Sierra Estrella mountains, along the base of which is a narrow belt of giant cactus that furnishes food for the white-wings.

No serious estimate of the population was attempted but searches in widely scattered parts of the thicket proved that nests were distributed throughout the area. In 1938 more than 300 nests were located in a small fraction of the colony and it seemed certain that the total population ran to several thousand pairs. Most of the 1938 nest studies and all of those for 1939 were made in what is hereafter termed the Santa Cruz thicket.

METHOD OF STUDY

To minimize disturbance to the brooding birds which commonly left the nest with explosive suddenness, nest searching in the thickets was carried on as deliberately and quietly as possible. Every effort was made to cover the study area methodically and completely, though it is amazingly easy to wander in circles in such vegetation where there are no visible landmarks. After locating a nest in mesquite it was necessary to climb sufficiently near so that the contents could be inspected; at Sacaton the tamarisk was entirely too flimsy for climbing and most of the nests were inspected by young Jerry Lawhorn, son of the Federal Game Management Agent, lifted at arm's length overhead.

Profiting from the strenuous labor of the 1938 season, a nest-viewing apparatus was devised in 1939. A light pole was cut into three four-foot sections and ferrules were affixed; to the end of one section was attached a mirror adjustable to the desired angle by means of wire springs (Plate 7-A). With this apparatus the contents of every nest up to a height of about 20 feet was viewed clearly, with little expenditure of time or energy.

After identifying the nest and recording its contents a waterproof tag carrying the catalog number was affixed, and an easily visible cloth streamer was tied to the tree in which the nest was located. In 1938 white cloth was used, but in 1939 it was found that bright orange cloth made a more effective and

visible flag. As work in the thickets continued, the nests were visited from time to time and developments recorded.

MORTALITY AND PREDATION

Disturbing factors were several. The frightening effect of the study itself caused the wrecking of several nests as the departing adult tossed eggs or tiny young from the nest in explosive departure. Upon cautious approach however, one might come within a few feet without the adult flushing. Woodcutting caused serious confusion in the Santa Cruz thicket during both seasons; this thicket is the source of wood both for the Indian's domestic use and for commercial sale, and during both 1938 and 1939 cutting operations were extensive. Indian horses and cattle run at large throughout the thicket and frequently crash through the mesquite with such violence as to flush sitting doves. Numbers of nest tags and flags disappeared, probably being removed by Indians. In the Sacaton thicket Indians with sling-shots apparently took some birds.

There was little concrete evidence of predation. Coyotes and Indian dogs were present in numbers and ate those young birds that fell to the ground. Other mammals noted were all rodents, including ground squirrels, rats, and mice. Avian species of possible influence were screech owls, barn owls, and road runners, but no direct evidence of predation by them was discovered. Snakes were not abundant, and those observed consisted of rattlesnakes, a king snake, a gopher snake, and two that on brief glimpses appeared to be black whipsnakes.

Some eggs and young disappeared, but it seemed impossible to ascertain definite causes for most of the losses. Juvenile mortality is definitely increased by the activities of men, horses, and cattle in the nesting thicket. In addition to the instances in which a brooding adult accidentally threw eggs or young from the nest when frightened suddenly, it was found that when the adult departed from the nest precipitately after the young had reached the age of ten to twelve days, one or both young were very apt to jump from the nest and fall to the ground, an easy prey for predators.

RESULTS OF THE NESTING STUDY

In Tables 1–4 are summarized the data resulting from a study of 661 nests. Tables 1 and 3 give the findings of the day-by-day search for nests in 1938 and 1939, respectively; Tables 2 and 4 segregate the data into time-periods to enable easier analysis of their relation to various open shooting periods. The age-classes for the young birds are based on experience gained by observing nests of known age. These arbitrary age-divisions are not absolutely accurate since they do not take into account possible variations, yet they are sufficiently correct to permit practical interpretation.

At the close of each season's study an attempt was made to obtain an idea of the probable success of nesting by a close inspection of the nests. The presence of eggshell or of a heavy pad of fresh excrement were accepted as indications of probable success, while the absence of feces, in particular, was taken as an indication of failure; in many instances the evidence was so incomplete that no decision was pos-

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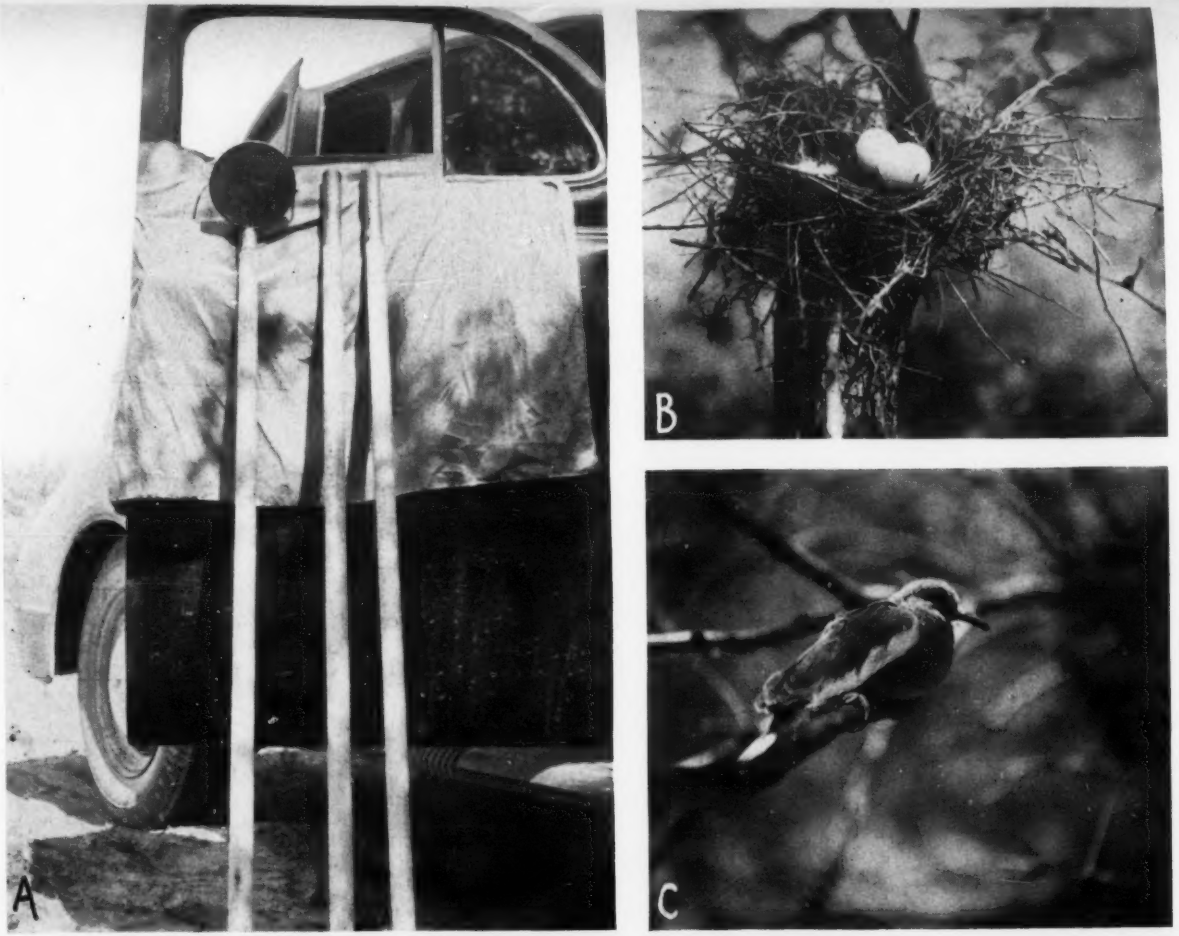

A (*left*).—Nest-viewing mirror; three sections of light pole provided a handle 12 feet long. B (*upper right*).—White-winged dove nest in mesquite, July 21, 1938. C (*lower right*).—Young about 18 days old, July 21, 1938.

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TABLE 1

SUMMARY OF THE CONTENTS OF 400 WHITE-WINGED DOVE NESTS OBSERVED IN 1938

Date found	Bird flushed from clean empty nest	Eggs		One egg and one fresh-hatched squab	Squabs 2 to 5 days		Squabs 6 to 10 days		Squabs 11 to 15 days		Squabs 16 days up to flying stage		Total
		1	2		1	2	1	2	1	2	1	2	
6/23*	–	–	1	–	–	–	–	–	–	–	–	–	1
6/24*	–	–	2	–	–	–	–	–	–	–	–	–	2
6/29**	1	–	6	–	–	–	–	–	–	–	–	1	8
7/ 1**	1	2	20	1	2	4	1	2	–	2	–	1	36
7/ 2**	1	4	13	1	1	–	1	–	1	1	–	1	24
7/ 4	1	2	5	–	1	1	1	–	–	1	–	–	12
7/ 5	–	2	18	–	1	1	2	–	–	1	–	–	25
7/ 6	–	–	35	–	–	1	–	2	3	2	–	–	43
7/ 9	–	–	12	–	–	1	–	–	–	–	–	–	13
7/11	2	4	13	1	1	2	1	2	–	1	1	2	28
7/13**	2	1	19	–	2	1	3	–	2	1	–	–	31
7/14	–	1	18	–	–	2	–	1	3	3	–	4	32
7/15	1	–	4	–	–	7	–	–	–	2	–	–	14
7/19	–	1	8	–	–	1	1	1	–	1	–	1	14
7/21	–	4	12	–	1	5	1	3	1	1	–	–	28
7/22	–	–	9	–	1	4	–	1	1	–	–	1	17
7/26	–	2	16	–	–	2	–	1	–	1	–	–	22
7/28	–	–	1	–	–	–	–	–	–	–	–	–	1
7/29	–	–	9	–	–	–	–	1	–	–	–	–	10
8/ 2	–	–	12	–	–	1	–	–	–	–	1	1	15
8/ 3	–	–	11	1	–	–	–	–	–	–	–	–	12
8/ 4	–	–	3	–	–	–	–	2	1	–	–	–	6
8/ 8	–	–	–	–	–	–	1	–	–	2	–	–	3
8/17	–	–	–	–	–	1	–	1	–	–	–	–	2
Totals	9	23	247	4	10	34	12	17	12	19	2	12	400

* Miscellaneous desert nests.
** Tamarisk thicket at Sacaton.

sible. On this basis, in 1938 about 31% of the nests were recorded as successful, and 15% unsuccessful, while the fate of 54% was unknown; in 1939 about 29% were successful, 14% unsuccessful, and 57% unknown.

TABLE 2

SEGREGATION OF THE WHITE-WINGED DOVE NESTS LISTED IN TABLE 1 ACCORDING TO CONTENTS DURING FOUR PERIODS

Period	*Eggs*	*Young fresh-hatched to about 10 days of age*	*Young from 10 days of age to time of leaving nests*
June 23–June 30	9	0	1
July 1–July 14	174	40	29
July 15–July 31	61	30	9
August 1–August 17	26	7	5
Sub-totals	270	77	44
Total occupied	391		
Unused empty nests	9		
Grand Total	400		

TABLE 3

SUMMARY OF THE CONTENTS OF 261 WHITE-WINGED DOVE NESTS OBSERVED IN 1939 (SANTA CRUZ RIVER THICKET)

Date found	Empty nests	Eggs			1 egg 1 fresh-hatched squab	Squabs 1–5 days		Squabs 6–10 days		Squabs 11–15 days		Squabs 16 days or more		Totals
		1	2	3		1	2	1	2	1	2	1	2	
5/16	–	–	2	–	–	–	–	–	–	–	–	–	–	2
6/ 6	1	4	36	–	–	1	7	2	2	–	1	–	–	54
6/ 7	3	1	27	–	–	–	9	–	5	1	–	–	2	48
6/28	2	1	8	–	–	–	1	–	1	–	–	–	–	13
7/12	–	1	18	–	2	–	9	–	2	–	2	–	2	36
7/13	1	2	16	1	2	4	10	–	4	–	2	1	6	49
7/25	–	3	11	–	–	–	4	–	–	–	2	–	1	21
7/28	–	3	16	–	–	3	3	1	–	–	1	–	7	34
8/11	–	–	3	–	–	–	1	–	–	–	–	–	–	4
Totals	7	15	137	1	4	8	44	3	14	1	8	1	18	261

SEASON OF NESTING

Swarth (1920) reported a sitting bird near Tucson on April 13. Wetmore (1920) working near Arlington from June 2 to 21, 1919, stated that when he arrived he found birds feeding young, but that others were still building nests on June 17. Deputy Game Warden Peterson states that the first white-wings appear in the mountain canyons near Nogales in late March and early April; in these canyons, mostly above 4,000 feet in elevation, he considers that nesting is usually well under way by May 1, and nearly all of the young birds on the wing by July 1.

With one exception, the arrival date of the birds in the Phoenix district has for the past 15 years fallen within the period April 22 to May 8. In the Santa Cruz thicket colony nesting was just beginning on May 16, 1939; two nests contained fresh eggs, several nests were only partially completed, and many females were observed apparently searching for nesting locations. At Payson, 6,400 feet, a pair was completing its nest on May 29, 1939.

Late nesting extends well through the summer (see tables). Peterson and the writer found a nest containing fresh eggs near Patagonia on July 20,

TABLE 4

SEGREGATION OF THE WHITE-WINGED DOVE NESTS LISTED IN TABLE 3 ACCORDING TO CONTENTS DURING FOUR PERIODS

Period	*Eggs*	*Young fresh-hatched to about 10 days of age*	*Young from 10 days of age to time of leaving nests*
May 16–June 30	79	28	4
July 1–July 15	38	33	13
July 16–July 31	33	11	11
August 1–August 15	3	1	0
Sub-totals	153	73	28
Total occupied	254		
Unused empty nests	7		
Grand Total	261		

and a hunter reported finding a nest and eggs near Salome on August 5. Carlos Stannard observed an incubating bird near Phoenix on August 12. Chas. P. Beach watched three nests near Vail where incubation continued to August 20 and 27, respectively, and from one of which the young departed September 17.

Well-developed eggs were found in females killed near Patagonia in early August, as well as in one collected near Gila Bend on August 2. Near Salome on August 9 and 10 three out of 10 adults shot still retained milk cells in their crops. Six males killed near Mohawk on August 3 all had greatly enlarged testes, and the crops of two contained traces of "pigeon milk". Even so late as August 22 and 23, 1939, crops of birds shot in Dendora Valley near Gila Bend contained remnants of milk cells.

The data obtained in the Santa Cruz thicket definitely proves two rather distinct periods of nesting, and indicates the rearing of two broods by a considerable proportion of the population. The first-brood nests are built in mid-May, and the young birds leave during the latter part of June. The second-brood nests are begun late in June and early in July, and the young are fledged in late July and early August. As might be expected, the second brood does not appear to be as numerous as the first. Late nests found sparingly away from colonies also probably represent second attempts at brood production. Mr. Beach's several years of observation of white-wings at his Vail ranch have convinced him that many of the birds rear a second brood. It is the writer's opinion that in the desert, in the higher mountains, or in any location where food, water, and cover are sparse or unfavorable, there is, on the average, but one brood a season, but that in areas where conditions are highly favorable there is a well developed second brood.

FAVORED NESTING SITES

Dense river bottom jungles of mesquite, tamarisk, or other vegetation are the preferred nesting habitats for white-wings. In mountain canyons the birds appear to prefer oak trees. In the Santa Cruz River bottom near Tumacacori National Monument the nests were largely built in shrubs of Condalia. Scattered nests in both desert and farming districts were found in a variety of growths, including mesquite (*Prosopis*), screwbean (*Strombocarpa*), palo verde (*Cercidium*), ironwood (*Olneya*), tamarisk (*Tamarix*), catclaw (*Acacia*), giant cactus (*Carnegiea*), Condalia, willows, cottonwoods, cholla cactus, eucalyptus, Arizona cypress, olive, various citrus, and deciduous fruit trees, a variety of ornamental shade trees, and in clumps of mesquite mistletoe (*Phoradendron*).

HEIGHT OF NESTS

The lowest nest recorded was in the main crotch of a desert ironwood near the Superstition Mountains, barely five feet above the ground. Nests in Condalia near Nogales were built at heights of from five to eight feet, while those in oaks in the southern mountain canyons were considerably higher. In the Sacaton nesting colony the elevations were from six to 14 feet, with an average of nine feet, while in the Santa Cruz colony they ran from seven to about

24 feet, with an average of about 12 feet. The highest nest observed was nearly 40 feet from the ground in a cottonwood.

NEST STRUCTURE

The nests are built almost entirely of dead twigs picked up in the immediate vicinity, thus generally are the product of the tree in which the nest is built. In the oak canyons of southern Arizona the thick and bulky nests were made entirely from dead twigs of the oaks; in some of these canyons band-tailed pigeon nests also were found, and it was extremely difficult to differentiate between the two kinds. Nests in Condalia near Nogales were also largely built of dead twigs of oak, which grew quite abundantly in the vicinity, and were similar in size and shape to the nests in oak trees.

In the mesquite thickets, nests were made almost entirely from small dead twigs of mesquite, and in the Sacaton thicket they were made from dead tamarisk twigs. Nests on the desert were made from twigs of mesquite, catclaw, palo verde, or ironwood, obtained under these growths. One nest in a high cholla cactus appeared to be made from stems of woody desert plants, with possibly some grass, but could not be closely examined. Excepting for the oak twig nests, the usual white-wing structure is flat and small, very slightly bulkier than that of the mourning dove. Often it is possible to see the contents through openings in the nest material.

Some newly constructed nests are not occupied for several days after completion; whether or not it is the builder that finally occupies the nest is not known. A number of nests marked in 1938 were found reoccupied in 1939. Nests inhabited in June by the early brood were frequently found used for a second brood during late July.

EGGS

The normal set is two eggs (Plate 7-B); there is only a small percentage of one-egg nests; and only one nest thus far studied has contained three eggs. (This was robbed before hatching.) The eggs are distinctly buffy-white in color, dull, and easily distinguishable from those of the mourning dove, enabling accurate identification of many nests where no adult was seen. Measurements of small series of eggs ranged from 21.0×29.0 mm. to 23.0×33.0 mm., and averaged 22.5×30.7 mm. The eggs may be laid on successive days, or at intervals of one or two days.

PERIOD OF INCUBATION

Deputy Game Warden Peterson watched three nests in Protrero Canyon near Nogales in June, 1939; the eggs in one of them hatched on the 19th day, and in the other two on the 20th day. Stannard made observations on several nests near Phoenix and all hatched between the 15th and 17th days; this period was found to be normal for nests under observation in the Sacaton and Santa Cruz nesting thickets, and agreed closely with the findings of Beach at Vail. The variation noted is no doubt due to the difference in temperature between the base-level desert at Phoenix and Protrero Canyon at nearly 4,000 feet altitude.

Wetmore (1920) was of the opinion that males did not assist in the incubation, and neither Beach, Stannard,

nor the writer have made any contradictory observations.

GROWTH OF THE NESTLINGS

Wetmore stated that the young left the nest when from three to four weeks old. In the studies personally conducted it was found that at any time after the 12th day the young were likely to jump from the nest if the brooding adult was frightened off, and that at this stage none of the nestlings could fly well enough to reach even the next tree. Most of the nestlings took flight between the 15th and 18th days (Plate 7-C). In some instances young still in the nest were observed to have attained a fullness and smoothness of plumage that, judging from nestlings of known age, could not have been reached before the 20th day or later. Of the nests watched by Stannard, one was deserted on the 14th, and all the others on the 15th day. Beach, however, reports that all of the nests he was observing were abandoned on the 12th and 13th day after hatching.

Both adults assist in the care of the young birds. Wetmore stated that he observed both parents sitting on the edge of a nest containing young, but neither Beach, Stannard, nor the writer has made a parallel observation. One instance has been reported in which a hunter shot an adult whitewing on August 1, 1938, only to find that it had flushed from a near-by nest containing young; inspecting the nest a week later he flushed the other adult and found both young in good condition. Mr. Beach had two nests in full view of his study window during 1939. At 7:45 A.M. on a June day the bird brooding week-old young in one of the nests was heard hooting vigorously; soon its mate arrived in the tree and the brooding bird departed; slowly the new arrival took its place on the nest. This change was noted at the same hour each day for several days, but Mr. Beach was unable to continue the watch throughout the day; on one day he saw the birds change places also at 2:00 P.M.

The young are fed by regurgitation, and according to Wetmore received solid foods at the age of four days in addition to "pigeon milk." After beginning the feeding of solids it appears that the adults give the nestlings virtually the same food that they themselves are taking, for seeds, grain, and the pulp of giant cactus, have been found in the crops of half-grown nestlings.

Often the young birds hatch on successive days just as the eggs were deposited. When first hatched they are tiny, covered with fine buffy-white down, and easily dislodged from the scanty nest by too-abrupt departure of a parent. Growth is rapid and at the end of the first week a nestling is a grotesque mass of long feather quills just beginning to burst open. At two weeks of age the youngster is far developed, the wings appearing of normal size with the white bar very pronounced, though often carrying dark spots; the tail, while also showing its white bar, is very short and if flight is attempted does not rudder well. During the third week the tail reaches normal length, the white bars become clear, and by the end of the third week the nestling attains a smoothness and fullness of plumage closely similar to that of the adults.

In the Santa Cruz mesquite the young birds, after leaving the nests, apparently remained in the thicket for some days; they were often seen walking about on the ground in fairly open parts of the thicket, or perched in trees. There was no evidence of young birds joining the flight of adults to the feeding area of giant cactus some five miles to the westward, and no juveniles were collected in the cactus.

Thus the young birds appear to be dependent upon the parents for a considerable period after leaving the nest. On the Mexican border near Douglas on July 20, 1939, warden Morrow and the writer saw one young white-wing among several hundred mourning doves feeding on chaff and other feed lot waste that had been dumped among the mesquite. During a considerable period of observation the white-wing juvenile made no attempt to locate or pick up food from the chaff; instead, it watched intently until a near-by mourning dove picked up a grain, then ran forward begging with open mouth and slightly outstretched wings. On September 17, 1939, seven immature white-wings visited the location where Mr. Beach kept milo maize scattered for the mourning doves; none made any attempt to pick up a kernel of food, but all ran from one to another mourning dove begging.

Juvenile birds collected at various stages have been weighed. Three nestlings about 10 days old weighed from 74 to 77 grams. Older juveniles collected in flight during the August open season and during the last few days of July, just prior to the opening of shooting, scaled from 93.0 to 131.5 grams. Birds of the lower weights were very definitely not sporty shooting, being slow and weak of flight and unwary. In the writer's opinion juvenile white-wings do not offer real sport shooting until they have been at least four weeks out of the nest.

ROOSTING

After the young leave the nest they frequently roost for one or two nights in the nest-tree or in one close by, accompanied by one of the adults. Mr. Beach, reporting on a brood that left the nest on June 11, stated that until June 26 the two young and one adult roosted on the same branch in an adjacent palo verde; on June 26 the young appeared at the roost alone, and continued to sleep on the same branch until June 29; the birds were then absent until July 10, when two young thought to be the same returned to the identical roosting spot for four consecutive nights.

During the nesting period the male adult roosts in the same tree with the nest or in a closely adjacent tree; the quantity of excrement on the ground usually makes it easy to locate this roosting spot; it is thought that this roost is frequently the same perch that is used as a day-time guard post. During the flocking period as the birds move about seeking food and water it appears that an entire flock repairs to near-by cover to rest; many of these roosts are in dense mesquite thickets along the river bottoms, from which the birds fly to and fro to feed on near-by agricultural lands. The desert flocks repair to mesquite, palo verde, and ironwood cover growing along the

banks of washes or canyons. Stannard reported that in mid-July, 1939, a flock of about 40 birds came regularly to roost in a group of pepper trees on his ranch.

VOICE

Wetmore (1920) described calls of the male white-wing, but ascribed none to the female. Mr. Beach's observations on calls in connection with the exchange of brooding duties have been quoted; it was his opinion that the female brooded during the night, and was relieved by the male at 7:45 A.M. He stated that the bird brooding during the day hooted frequently, but was unable to say whether further shifts in brooding occurred excepting for one record of a change at 2:00 P.M. Thus it appears that the female may at times take part in the calling or hooting that is so prominent a feature of a nesting colony. The writer has spent many hours watching brooding birds presumed to be females, without noting any calling; females have been heard to take part in a low guttural chatter that appears to be stimulated by an intruder at the nest.

SUMMARY

The gathering of information concerning the nesting of the white-winged dove was the primary objective of two seasons of field work in Arizona. While isolated pairs of the birds nest locally throughout their range it seems probable that the number of large nesting colonies is being gradually reduced. In two colonies studied, interference by man was found to be the greatest cause of mortality. Little evidence of predation was observed.

The nesting season extends from April 13 to September 17; in the Phoenix district major nesting occurs between May 15 and August 15. Where conditions are favorable two broods are reared and young may be in the nest until mid-August. Where unfavorable conditions prevail there is only one brood that is largely on the wing about July 1.

Nests have been found in numerous kinds of trees and shrubs, with mesquite the most favored. Elevation of nests ranged from five to about forty feet. Nest structure varies with the location, but nests are generally made from dead twigs of locally abundant trees. Eggs are buffy in color and without lustre, easily distinguishable from those of the mourning dove. Two eggs are a normal set; three were found in one nest. The period of incubation near Phoenix was recorded as from 15 to 17 days; at the considerably higher elevation of Nogales 19–20 days were required.

At Vail, nestlings abandoned the nest on the 13th day and at Phoenix, on the 15th and 16th days, while the writer records departure from the nest commonly from the 16th to 18th days with a few juveniles remaining 20 days. Both adults assist in caring for the young, which remain dependent for some time after leaving the nest. Growth of the young is traced and sample weights are given. Juveniles are not suitable for sport shooting until about a month out of the nest.

COOPERATION

The number of friendly cooperators who have aided the investigation is too

great for individual mention. Biological Survey employees, representatives of other governmental agencies, and the entire staff of the Arizona Game and Fish Commission have freely extended every assistance, as have numerous sportsmen. Their whole-hearted aid is gratefully acknowledged.

Special appreciation must be extended to Federal Game Agent Thos. R. Lawhorn who has been guide and co-observer, and to his son Jerry who in 1938 climbed literally hundreds of thorny mesquites to inspect nests, and who did not make a mistake in identification. Special aid in locating nests and in observing nesting activities was received from Deputy State Warden Neill of Phoenix and Warden Peterson of Nogales. Interesting and valuable reports on the nesting of white-wings on their respective ranches were received from Carlos Stannard, ornithologist, of Phoenix, and from Chas. P. Beach of Vail, chairman of the Arizona Game and Fish Commission.

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HISTORY OF THE RILEY GAME COOPERATIVE, 1931–1939

Aldo Leopold

In 1940 the Riley Game Cooperative will celebrate its ninth birthday.

Any farm game organization which promises to survive a decade is worth describing, for most of them die in infancy. Of some 350 started in the north central region since 1931, the survivors in 1936 (1) could be counted on five fingers. The most vigorous survivals today are in Ohio (2).

Of the six projects started in Wisconsin, two remain: Faville Grove (3) and Riley. This is the history of Riley.

Organization

One Sunday in the summer of 1931 I was cruising western Dane County, looking for a place to hunt during the approaching season. I stopped at a farmyard for a drink of water. The farmer, R. J. Paulson, was washing milk cans at the well. We talked game. He needed relief from trespassers who each year poached his birds despite his signs; I needed a place to try management as a means of building up something to hunt. We concluded that a group of farmers, working with a group of town sportsmen, offered the best defense against trespass, and also the best chance for building up game. Thus was Riley born.

The Riley group now includes 11 farmers and five town members. The farm members furnish the land and also fencing, grain, and work. They have no cash outlay; the use of the land constitutes their "dues."

The town members furnish the operating funds and also help with the work.

All members share equally in the shooting, rules for which are drawn at an annual meeting. Current business is transacted by a committee of two "spokesmen," one for the farmers and one for the town group. There is no constitution, no by-laws.

The history of Riley has been affected by several events not foreseen at its inception; one was the passage of the Shooting Preserve Law soon after we organized in 1931. This law authorizes the Conservation Commission to license pheasant shooting preserves on which special seasons and bag limits may obtain. Instead of the usual 10-day season, a preserve may shoot from October to January. Instead of the usual bag limit of 2 cocks per day, a preserve may shoot, during the year, 75 per cent as many pheasants as it releases, without restriction as to sex. This season limit is enforced as follows: the local warden counts the birds released, and upon his certification the Department issues non-reusable tags, the number of tags being 75 per cent of the count. A tag must be attached to each bird killed. When breeders are released in spring, each hen counts as four prospective pheasants, and each cock as one.

Riley has been licensed as a preserve since 1931. The town members buy eggs and pay one of the farmers' wives for rearing the pheasants. We pay 50 cents per bird at eight weeks, at which time the warden makes the count and the birds are weighed and banded. After eight weeks the birds cease re-

turning to the brooder coops and "go wild." Those killed during the shooting season are distinguished from birds of wild origin by their bands.

Another unforeseen event that affected Riley was the appointment of the author to the Chair of Wildlife Management, University of Wisconsin, in 1933. Since that time the area has served the dual purpose of a shooting ground for members and an experimental area for the University. Each year since 1936 a graduate student has been assigned to Riley. During weekends and vacations he makes censuses, conducts experiments in feeding and banding, and supervises plantings. He keeps all technical records. A complimentary shooting membership is voted to the student by the members, but he receives no other compensation.

DESCRIPTION

The Riley area is dairy country, closely grazed and cultivated, hence deficient in both winter food and winter cover. The average farm comprises 160 acres and maintains 25 cows and 35 hogs. Pastures occupy the creek bottoms which are too wet, and the ridges which are too stony, to plow. The only ungrazed cover consists of woodlots isolated by fields, bogs too soft for cattle to enter, and odd corners. To these has now been added a system of small fenced evergreen plantations or remises. The winter food, other than feeding stations, consists largely of crop residues (corn and soybeans) accidentally left in the fields, manure spread on the fields, and ragweed aftermath on oat stubbles. The composition of the area by cover types is shown in Fig. 1 and in Appendix A.

The original vegetation was prairie, interspersed by groves of bur oaks. After farming had checked the free sweep of prairie fires, new stands of black and red oak seeded in on the prairie slopes and ridges. These post-settlement encroachments constitute the bulk of the present timber, which consists of scattered veterans of bur oak, branchy and open-grown, surrounded by even-aged black and red oaks grown in denser stands and dating from the Civil War or just before. Some roadsides still show relics of the prairie flora: prairie dock, lead plant, blazing star, butterfly weed, bluestem grass, and rattlesnake-master.

Riley lies at the foot of the terminal moraine of the Wisconsin glacier. Sugar Creek, the principal stream, drained the melting front of the ice sheet. The area is underlain by St. Peter's sandstone, which shows frequent outcrops, and by Galena dolomite. All the uplands are eroding, hence Sugar Creek is subject to sudden floods at all seasons.

Riley presents two major ecological problems: the gradual transfer of fertility from upland to bottoms by erosion, and the gradual elimination of cover by grazing.

This paper presents no remedy for the erosion problem. If the uplands grow too poor to raise corn, the farmers will be forced to ditch and cultivate the bottoms.

The cover deficiency is clearly increasing with time. Cutting in woodlots where cows prevent reproduction means the gradual elimination of woods. With each succeeding drouth, new marshes are plowed; their tussocks are cover of a sort, even when grazed bare. As uplands erode and are

RILEY GAME COOPERATIVE
Dane County Wis.
171.5 Acres

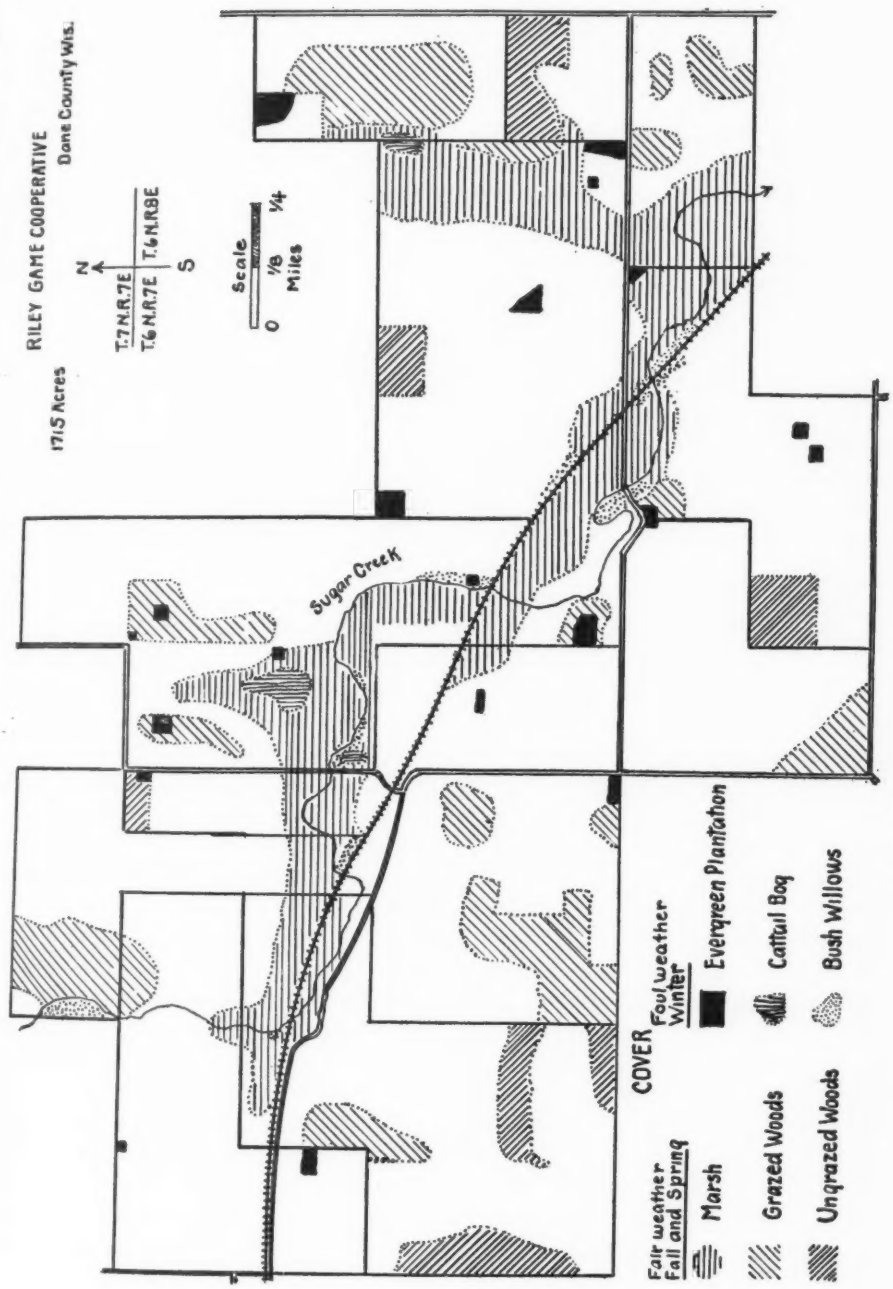

Fig. 1. Cover map of Riley Game Cooperative.

turned to pasture, the survival of fencerows becomes more difficult. Finally, since the C.W.A. year (1934) Riley has suffered a continuous loss of roadside cover through debrushing by highway crews. Before C.W.A. debrushing was done every few years when needed, and helped wildlife by keeping the roadside in desirable shrubs and forbs. Today debrushing is done yearly or even twice yearly, and with constant regrading makes the roadside a refuge for quack grass.

The railroad right-of-way shows an opposite trend, and partly offsets the loss of cover on roadsides. It was formerly burned each year, but at our request is now cleared only when woody growths get too large. The railway strip is now the best cover on the area, and is closed as a refuge.

FOOD AND COVER IMPROVEMENTS

The Riley cooperative in its early years was a simple effort to increase game by quick and easy measures like restocking and winter feeding.

When Riley became a university project it expanded its aims and its audience and now deals with all wildlife, and with slow and difficult measures like planting cover. It aims to prove that the downward trend of wildlife in the dairy belt can be reversed by the combined efforts of farmers and sportsmen, without large expenditures either of cash or land.

Winter Feeding. Ten stations are operated from November to March. They require each year 40 bushels of corn worth $25. Corn was at first bought and fed by the town members; it is now furnished and fed by the farmers. During the present winter a "boys' club" consisting of the sons of farm members has done most of the feeding.

Food patches supplemented by hoppers were tried at first. The patches were abandoned because it is the local custom to turn hogs loose on stubbles in fall. Hoppers are inconvenient because some of the farmers lack corn shellers. The feeding method now in favor is throwing ear corn on straw piles under shelters. Some of the ears are shelled into the straw to induce the birds to exercise. Some farmers feed the weed seeds that gather under corn shredders. Such seeds are excellent, but must be dried to prevent heating.

We at first fed in both upland and lowland coverts. Experience showed that pheasants and quail gravitate to marshes with the onset of severe weather, hence we no longer maintain many upland stations. Later on, when the new plantations develop dense cover on uplands, it may be possible to hold birds there in winter.

Cover Plantings. Riley offers a considerable acreage of fair-weather cover good for spring and fall use, but very little foul weather cover efficient against deep snows and hard blizzards. The aim of the cover plantings is to bolster existing fair-weather coverts with spots of denser vegetation, and to create new dense coverts on areas now bare.

Fair-weather cover now occurs on about 300 acres, or 17 per cent of the area. It consists of grazed tussock marsh (*Carex stricta*), brushy ungrazed woodlots isolated by fields and too small to fence as pastures, and brushy grazed woodlots where for some unknown reason the hazel and gray dog-

wood brush has not been browsed out by cattle or choked out by sod.

Foul-weather cover now occurs on only one per cent of the area. It consists of cattail bogs too soft for cattle to enter, bush willow along streams and railroad tracks, and grape tangles or plum thickets in fencerows.

It was evident from the outset that doubling or trebling the one per cent of dense winter cover by plantings would give a much better balance between the two classes at a negligible cost in agricultural acreage. It was not evident, however, what to plant, where to plant, or how to plant. This we had to learn through experience.

Willow plantings for cover were tried in pastures as early as 1931, but all succumbed to browsing.

In 1934 a C.W.A. crew fenced 21 units in which 1,300 plants were set out, mostly white and Norway spruce (2-0 stock), red cedar, grape, viburnums, and mulberry. All succumbed to the 1934 drouth. The weak fences built of scrap wire were all breached by cattle.

In 1936 a volunteer crew of students and farmers built five units of good fence. Fortunately no plantings were made, for this year brought the most intense drouth in local history.

In 1937 the Soil Conservation Service gave us a C.C.C. crew to plant the new units, and to build and plant eight others totalling seven acres. Strong 2–2 and 2–3 stock was used, mostly red pine, and despite a considerable drouth the survival ran from 70 to 90 per cent.

In 1938 and 1939 the farmers did their own planting, built their own fences, and some even hoed the trees throughout the summer. Good rains fell in 1938. Despite a considerable drouth in 1939, losses were negligible. The farmers no longer want relief labor crews, for the annual "tree planting bee" has become an enjoyable social event.

These cover plantings constitute a remise system (4) which will double the area of foul-weather or true winter cover. The cover pattern, including remises, appears in Fig. 1. The planted remises are not yet large enough to function as cover, but the oldest will come into service during the next few years. The test of their success will be whether a further increase in kill occurs during this period (see Fig. 2).

The decade of experience may be summed up as follows:

(1) Riley now has 18 fenced remises of young evergreens, mostly red or Norway pine, aggregating 12 acres. Most of these plots include extra area for grass cover, and for later plantings. Fenced remises will eventually be increased to cover two per cent of the area.

(2) The most promising remises are those in which strong 2–2 or 2–3 red pines were planted on sandstone hills. The farmers are willing to give these sites because they are too dry for pasture and too rocky for plowland. Wild stands of red pine occur on similar land at Pine Bluff, about five miles from Riley. The trees are planted 6′×6′ on 3′ scalps, and are hoed for one or two years. They make cover the fifth year.

(3) On limestone (dolomite) outcrops where red pine does not thrive, red cedar is used. There is no cheap source of red cedar, for forest nurseries

do not grow it. They should, for cedar post plantations would have economic as well as wildlife value.

(4) Conifer plantings on lowlands, despite superior soil, are of doubtful practicability because of rabbit damage and choking by sod. Of the conifers. white spruce makes the best growth, but it has no chance against rabbits unless very large stock is used, or unless each tree is screened by a woven wire cylinder. Willows seem to be the most practicable planted cover for lowlands. Royal or yellow willow starts best from cuttings, and can be kept bushy by pollarding.

(5) Rabbits are a threat to all conifers, even red pine, if placed in cover. Plantings in the open are seldom attacked. Red cedar is not damaged.

(6) All plantings must be fenced, and only strong, durable fences will do. We are now planting red cedars between each pair of posts to assure a good fence in future years.

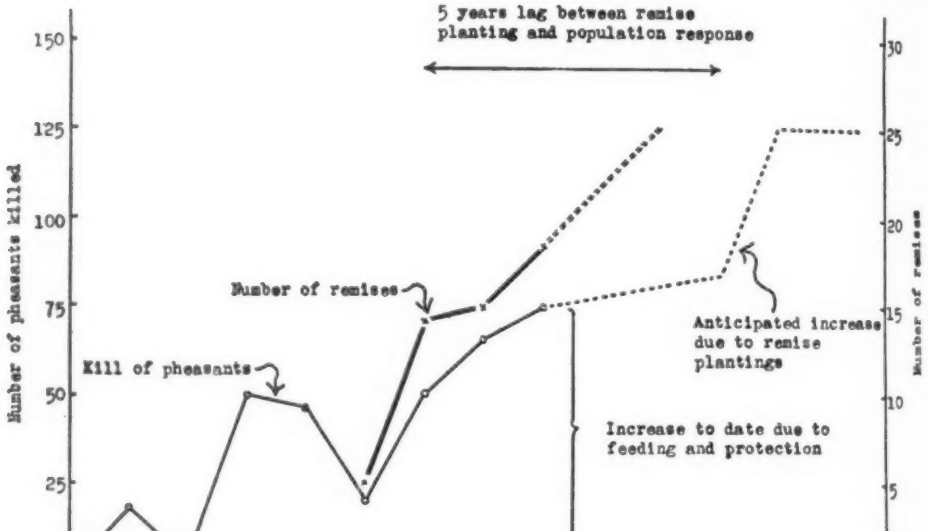

Fig. 2. Kill of pheasants and number of remises, Riley Game Cooperative.

PHEASANT MANAGEMENT

Stocking. Save for one stray cock seen in 1930, Riley was devoid of pheasants until we stocked the area in 1931. Shooting began in 1932. Stocking operations are summarized in Table 1. Since 1934 the annual August release has been around 100 birds eight weeks old. Since 1937 an additional small spring release has been made.

Pheasant Kill and Drift. The kill shows a steady increase through the decade. Its composition appears in Table 1 and its trend in Fig. 2.

The hunting pressure has remained quite uniform. The same men and often the same dogs hunt for the same period year after year. Some are poor hunters and get little or nothing after the first week or two. Some are good hunters, shoot cocks only, and can bag the wildest cock if there is one left on the area. The net result has been a decade of hunting of uniform and normal intensity.

probably the increasing population pressure outside. Riley drift has stocked the township, large outside plantings having been made during only the last two years.

Some birds still leave in winter, hence no census of the winter population has been attempted. Where these birds drift to we do not know. Wherever they go, they seem to return in spring, for there are always more cocks

TABLE 1
PHEASANT STOCKING AND KILL

Year	Releases		Legal quota of tags		Kill			Per cent tags used	Number of banded releases in kill
	Adults (spring)	Young (August)	Number	Per member	Cocks	Hens	Total		
1931		24	18		0	0	0		x
1932		70	56	6?	14	4	18	32	x
1933		0	0	0	4	1	5[1]	x	x
1934		119	91	6	31	21	52	57	x
1935		110	82	5–7[2]	28	18	46	56	x
1936		70	52	3–4	13	7	20	38	1?
1937	12	125	122	6–9	40	12	52	43	4?
1938	15	130	130	8	49	16	65	50	12
1939	12	99	84	5–12	48	29	77	92	7
Total	39	747	635	x	227	108	335	x	24
Average	x	83	71	x	25	12	37	53	x

[1] Tags carried over from previous year; this practice is no longer permitted.
[2] Quotas lumped on December 1; some members killed up to the second figure.

The pheasants respond to the combination of shooting, cold weather, and thinning cover by leaving the area. After the first week or two the season is closed outside, and this doubtless augments centrifugal drift. The tendency to drift outward, however, has decreased year by year; at first we were unable to kill more than a third of our allotment of birds; in 1939 we could, for the first time, have killed our full legal quota. The legal quota has been around 100 birds since 1934. One reason for the decreasing drift is crowing in spring than wintered at our stations.

Effectiveness of Releases; Banding. Since there were no pheasants prior to 1931, and since the kill has increased steadily ever since, it is safe to conclude that the early releases, made on empty or nearly empty range, survived and were effective. The gradual establishment of pheasants in the surrounding region occurred before large releases were made there.

In 1936 we began to mark our releases, partly to detect their recapture

in the kill, partly to trace the direction of the winter exodus. The bag of marked birds appears in Table 1, and is remarkable for its almost negligible proportions.

In 1936 and 1937 the releases were marked by punching a hole in the web between the toes. Tests on confined birds showed that such marks, unless made cleanly with a sharp punch, may close. Even if the hole remains open, it may tear out and become unrecognizable, or it may be overlooked. Hence the low returns from toe-punching (1 to 4 birds per year) are clouded by doubt as to their completeness.

In 1938 and 1939 releases were marked by colored celluloid and also aluminum leg bands, or, if the bird was too small to carry bands, by aluminum clips inserted in the web of the wing. Table 1 shows that of 214 releases thus marked during the last two years, only 19 (9 per cent) were bagged on the area. We were able to trace another dozen taken outside. Of 142 birds killed on the area since reliable marking began, only 13 per cent were artificially propagated.

We must conclude, then, that releases no longer count for much in the Riley bag; our steadily mounting kill comes not from current releases, but from the increasing wild population.

The fact that as many bands are returned from outside as from inside the area suggests that pen raised pheasants may be more susceptible to dispersion than are wild birds. This suggestion is supported by the fact that large groups of 20 or more bearing colored leg bands are seen on roads inside the area as late as September, whereas the October bags show as many outside as inside. It is also worthy of note that the instances of extreme dispersion (20 to 40 miles) reported yearly in the sporting literature usually represent game farm ringnecks, not wild pheasants.

Pheasant Economics. During the last two years the kill of 142 pheasants has cost us $200 in cash, or $1.40 per bird. This is well under the current price for shooting on commercial preserves, which runs from $2.50 to $3.00. However, our town members paid all the cash costs, but killed only two-thirds of the total bag, hence the cost of their take of birds was about $2.00 per pheasant.

That the licensed shooting preserve is an effective device for establishing pheasants in new regions is indicated by the history already given. It is not, however, an economical device for sustained yield from established populations. The restocking operations required by the shooting preserve law account for 70 per cent of our yearly costs at Riley, but bring us only 13 per cent of our bag. Biologically speaking, the state could absolve us of this cost, provided that it required us to prove, by suitable records, that we had created a sustained wild yield, and provided it required us, by tags, to stay within the proved capacity for such yield. That capacity at this time is the total kill (about 75) minus the number of released birds (about 10) or about 65 pheasants. Such recognition of wild production would greatly cheapen unit costs, and thus encourage the establishment of more preserves and more food and cover restoration.

Would such a policy lighten the

hunting pressure on outside range? Riley's 16 memberships represent about 25 shooters, who use 1,700 acres; i.e., 70 acres each. The outside hunter doubtless has less room. The probable effect of encouraging wild-production preserves would be to increase the total pheasant population and the total bag, to decrease the hunting pressure in time (because of long seasons), but to increase the hunting pressure in space by reason of outside crowding.

OTHER SPECIES

Bob-white. The Riley quail population mounted steadily from about 40 in 1931 to about 180 in 1935. Quail were then nearly wiped out by the killing winter of 1935–36. We have good censuses for subsequent Novembers: 1936, 65 quail; 1937, 53 quail; 1938, no record; 1939, 66 quail.

The Riley farmers refuse to permit quail shooting, even in years like 1935 when the season was open and the supply abundant.

No visible conflict between quail and pheasants has so far appeared.

Hungarian Partridge. This species had never been seen at Riley until 1937. In October of that year a wandering covey, drifting from the east by natural spread (5), appeared. In 1938 mated pairs were seen, and a hunter killed four from a covey just outside the boundary. In 1939, pairs, nests, and several coveys of young were seen. The advent of partridges promises new production from the large areas of upland too bare to carry quail or pheasants.

Ruffed Grouse. A remnant which seems never to exceed three birds has inhabited the ungrazed woods in the southwest corner since 1931.

Prairie Chicken. A flock appeared each winter from 1932 to 1935, but none have been seen since. There is no recent record of breeding.

Cottontail. These are abundant and remarkably stable in numbers. The flushing rates noted in my journal since 1936 show 48 rabbits in 42 hours, or 1.2 per hour during the hunting season. This index represents a population great enough to wreck plantations, and to consume a large fraction of the feed at stations.

There is a good deal of unauthorized boundary trespass by outside rabbit hunters. This is overlooked as long as no birds are molested.

Waterfowl. Ducks are occasionally seen on Sugar Creek during migration. In wet years the creek bottom pastures are excellent jacksnipe ground. A great gathering of snipes occurred in the fall of 1936. An intense drouth first caused overgrazing of all the pastures, and heavy fall rains then soaked and flooded the trampled soil. On October 16, 1936, I flushed 50 snipes in 30 minutes. Probably 150 were shot that year. In the average year I estimate the kill of snipes at 50 birds.

In drouth years when Sugar Creek recedes and leaves bare muddy banks, it is visited by woodcocks. This occurred in August of 1936 and September, 1939. None are known to breed.

Predators. Our members account for perhaps a half-dozen feral cats per year. Only one raptor has ever been killed by a member to my knowledge: a Cooper's hawk shot from a quail feeder in 1936.

Gray foxes are plentiful on the wooded hill in the southwest corner. In 1938, four grays were taken there by

one pack of dogs. Foxes now seem to be spreading over the whole area; this may be a response to the increased pheasant crop, or to the 1938–1939 high in mice.

Minks, muskrats, and a few raccoons occur along Sugar Creek. In 1938 two coons were taken by farmers, in 1939 none were taken.

In general, predator control at Riley has been casual, and in respect of hawks and owls, non-existent. Despite this, a steadily increasing head of game has been built up. Riley, then, is proof that in this region predator control is unnecessary.

Fish. Sugar Creek was formerly a good trout stream. It is supposed that increasing floods have now eliminated all but a few German browns.

One Riley farmer has a small spring-fed slough covering a quarter of an acre that is stocked with mud minnows. Bait dealers paid him $20 in 1938 and $21 in 1939 for seining privileges in this slough, a remarkably high economic return from so small a water.

PEOPLE

No farmer-sportsman group is stronger than the ties of mutual confidence and enthusiasm which bind its members. There was a time, about midway of its career, when enthusiasm at Riley faltered. We had lost two successive cover plantings through drouth, cattle breached our remise fences, we had some bad hatchings of pheasant eggs, and we suffered trespass from outside hunters who invaded the area via the railroad track. The organization nearly collapsed.

Riley was revived by Ellwood B. Moore and H. Albert Hochbaum, graduate students assigned to the area in 1936 and 1937, respectively. They rekindled enthusiasm, organized "planting bees," induced the railroad to post its tracks, and started an exchange of social events between the farm and town groups. Today the organization is very much alive. The annual Riley dinner is anticipated by the members quite as keenly as opening day on pheasants.

When hunters are taken out of the "devil-take-the-hindmost" atmosphere of free public shooting and become dependent upon their own efforts for sport, their attitude undergoes a remarkable shift toward conservatism. Thus at Riley the rules permit hens to be shot, but few members do it; in 1938 they carried their "chivalry" to such lengths that we had to buy cocks to rebalance the sex ratio. The rules permit a member to shoot his entire allotment of pheasants in one day, but the members seldom shoot more than one bird.

Some of the farmers have developed interests that extend far beyond game. Two of them, on their own initiative, have started an artificially planted tamarack grove, with the ultimate objective of reintroducing ladyslippers.

Riley has a waiting list of adjoining farmers who "want in." We have declined these expansions, believing that too large a membership would destroy the informality which is probably the key to our survival.

SUMMARY

Riley is a farmer-sportsman shooting preserve for which farm members furnish the land and town members the cash; both contribute labor and share

in the shooting. The university uses the area for wildlife studies.

The seasonal kill on 1,700 acres is now 75 pheasants. The area is fed and restocked, but there is no predator control. Banding shows that wild birds comprise the bulk of the kill, but restocking absorbs the bulk of the costs. The cost per bird in bag is $1.40. The pheasants disperse in fall and return in spring. Dispersion is decreasing.

If the law allowed, Riley could now abandon artificial restocking and kill 65 pheasants per year at 50 cents per bird in bag.

Planted remises of red pine cover 1 per cent of the area and furnish cover the fifth year. There is another 1 per cent of natural winter cover.

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APPENDIX

(A) *Vegetative Types in 1939*

	Acres	Per cent
Plowland		
Corn	219	13
Alfalfa	177	10
Small grains	234	14
Soybeans	24	1
	654	38
Grassland		
Pasture	650	38
Haymeadow	114	7
Ungrazed	7	0
	771	45
Woodland		
Pasture	222	13
Ungrazed woods	31	2
Ungrazed brush	25	1
Fenced plantings	12	1
	290	17
Grand Total	1,715	100

(B) *Rules for 1939.* Adopted at the Annual Meeting, October 12.

Open season. October 14 to January 1.

Cock rule. Either cocks or hens, but only 1 hen may be shot for each 2 cocks shot. After December 1 the spokesmen may modify the cock rule if they think conditions warrant.

Guests. Hunting privileges are limited to members and their immediate families. On rented farms the renter and owner together constitute one member.

Areas closed as refuges. (1) Right-of-way of C. & N. W. R. R.; (2) spring-hole on Paulson farm north of R. R. crossing; (3) fencerow between McCaughey and Brannan; (4) within 100 yards of any feeder containing feed.

Entirely protected species. Hungarian partridge, quail, ruffed grouse, prairie chicken.

Allotment. We have a total credit of 111 birds this year, 99 for young pheasants raised, 12 for cocks released last spring. Seventy-five per cent of 111 gives us a possible kill of 84 birds.

We have 16 members, plus one complimentary membership for the student, total 17. This allows 5 birds per member. After December 1, unused quotas will be lumped, and any member may shoot up to a season total of 12 birds.

Registration and tags. All tags will be kept at Paulson's. All pheasants killed should be promptly tagged, registered, and weighed. All releases are banded. If you kill a banded bird, please register the number.

Identification of members. To identify each other while hunting, members will raise the right hand when sighting other members.

(C) *Budget for a Typical Year*

	Expenditures	*Receipts*
5 town members at $20 each		$100.00
200 eggs for propagation	$ 20.00	
Rearing 100 pheasants at 50¢ (8 wks. old)	50.00	
Shooting preserve license	10.00	
10 metal signs for posting at 30¢	3.00	
Annual membership dinner	17.00	
Total	$100.00	$100.00

(D) *Personnel*

Farm Members: R. J. Paulson, Joe and Jerome Brown, O. M. Hub, M. G. Thompson, L. C. England, Wesley Riley, Hillery McCaughey, Albert Bohle, J. L. Henderson, William Cook, Joe L. Brannan.

Town Members: T. E. Coleman, A. W. Schorger, Howard F. Weiss, R. J. Roark, Aldo Leopold.

Students: 1936: Ellwood B. Moore
1937: H. Albert Hochbaum
1938: Lyle K. Sowls
1939: Bruce P. Stollberg

Aldo Leopold
University of Wisconsin
Madison, Wisconsin

PLANTING EYED EGGS: A METHOD OF FISH PROPAGATION IN REMOTE LAKES AND STREAMS

Raymond M. West

The stocking of remote lakes and streams in inaccessible areas has long been a major problem in fish propagation. The difficulties are probably nowhere better represented than in the Pentagon, Mission Mountain, and South Fork Primitive Areas of the Flathead National Forest, the principal fields of the operation here described.

The Flathead National Forest embraces approximately 2,500,000 acres of the rugged, mountainous territory lying west of the Continental Divide and south of Glacier National Park. It includes practically all of the upper Flathead River drainage, and is a recreational area of major importance. In past years the major drainages have been well supplied with native fish species, mainly through natural infiltration, and partly through artificial stocking with fry and fingerlings. Casual and informal contacts and observation in 1937 indicated that the fish resource was on the decline. Investigation showed further that many lakes and streams, especially in the Primitive Areas, were entirely barren due to physiographic obstacles that prevented natural stocking.

Through the efforts of John W. Schofield, State Superintendent of Fisheries; John Sheehan, Superintendent of Somers Hatchery, Somers, Montana; J. C. Urquhart, Supervisor of the Flathead National Forest; the author of this article; and local sportsmen's associations, a co-operative re-stocking program was adopted. In addition to the planting of fry and fingerlings, special attention was given to the more remote areas which, because of the difficulties of transport and expense, could not be stocked readily by ordinary means.

Stocking of Remote Areas Impractical

The stocking of back-country areas with fry or fingerlings is a difficult and expensive task beset with many disappointments. On any large scale it is impractical, since not more than 20,000 to 25,000 fry may be carried on a nine mule pack train. Considering the man-days and pack animal-days involved, the expense is prohibitive. The water in which fry or fingerlings are carried must be maintained at a temperature not exceeding 55°F., and must be continually agitated in order to insure aeration. On long trips of ten to twenty-five miles it is necessary to carry ice to keep the water temperature down, and if overnight stops are made, holding troughs must be improvised at each site. Water is continually splashing out of the carrying cans while pack mules are in motion, and on long, dry trails where no water is available the problem of replenishing the supply is acute. The transportation of fry and fingerlings by plane and dumping them in lakes by various methods is also expensive, and the success of such stocking is still open to question.

THE USE OF EYED EGGS

Of the alternatives considered in the re-stocking program, the use of eyed eggs showed the most promise. The eggs are designated as "eyed" because of the black eye spots of the embryo showing through their transparent shells. They reach the "eyed" stage in approximately twenty days incubation at 54°F. following fertilization, at which time they are within six to ten days of hatching. At this stage the eggs are tough and pliant, and may be packed and handled with little loss. When maintained at temperatures from 38° to 42°F. development may be retarded for from two to five days or longer. In this planting program, it was decided to use only the eggs of the cut-throat trout (*Salmo clarkii*), because that species is a native of the Flathead drainage.

FORMER METHOD OF PLANTING EYED EGGS

In past years eyed eggs have been used for stocking by placing them directly on the stream bed, and covering them with gravel, to simulate natural spawning conditions. This practice did not meet with favor due to the difficulty of making any accurate check on the hatch. Further, the eggs often became covered with silt and suffocated, and many were destroyed by fishes, birds, or insect larvae.

IMPROVED METHOD AND EQUIPMENT

Planting Trays. To overcome the hazards mentioned, a new method of planting eyed eggs was developed, and several items of special equipment were designed and built. Instead of placing the eggs directly on the stream bottom, they were planted in floating trays. These trays were fourteen inches square and three inches deep with sides and a removable lid made of wood and a bottom of hatchery screen wire (Chess Cloth) with an oblong mesh, which held the eggs but allowed the fish to wriggle through after hatching. For convenience in transport these trays were built in nests of three which would fit one inside the other. (Plate 8—A, Nos. 3 and 4, and Plate 9—C.[1])

Each tray was loaded with from 5,000 to 10,000 eggs depending on the intensity of stocking desired. The eggs were placed loose in the covered tray, floated out and anchored over moving water. Flowing water was necessary to keep the eggs stirred up so that any fungi attacking dead eggs would not infect the live ones. After hatching, the fishes dropped through the wire mesh bottom of the tray and burrowed in the gravel of the bottom of the stream, just as they do under natural hatching conditions.

The advantages of the floating tray were that it prevented fishes and birds eating the eggs, protected them from direct sunlight, and kept them near the top of the water, insuring movement of the eggs and a good oxygen supply; further, an accurate check of the hatch could be obtained since the unhatched eggs remained in the tray.

Transport Cases. Transport cases for carrying the eggs in bulk were designed and constructed of wood for use on pack animals. They were twenty inches long, eighteen inches high, and twelve inches wide, and were insulated with a three-inch packing of Zonolite. Holes were bored in the bottom to allow escape of excess moisture. Access to the

[1] All photographs by Henry Thol.

A (*Left*)—Equipment: (1) transport cases, (2) accessory compartment, (3) planting trays, (4) lids for planting trays, (5) ice case.

B (*Right*)—Ice tray and egg transport trays removed from transport case.

A (*Upper*)—Pack stock carrying 100,000 eyed eggs, planting equipment, and camping outfit.

B (*Lower left*)—Transferring eyed eggs from transport tray to planting tray.

C (*Lower right*)—Showing eyed eggs in planting tray.

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egg-compartment was through a hinged lid on top. Cracked ice was placed in an ice tray, four inches deep, on top of the transport trays in the case, so that the melting water seeped down on the eggs. A small accessory compartment was built on the back of the cases primarily for the purpose of making them ride level on a pack saddle. This compartment was used for carrying miscellaneous equipment, including ice pick, egg-picker, baling wire, pliers, hammer, and nails. (Plate 8—A, Nos. 1 and 2.)

Transport Trays. Transport trays of wood were built to fit in the egg compartment of the cases. They were approximately seven-eighths inches deep, open on top, and covered on the bottom with fine mesh wire screen. Each tray held sixteen ounces of eggs (approximately 4,700). For moisture retention and added protection against shock, the trays were lined with washed muslin. Thirteen of these trays with an ice container were the complement of one transport case. (Plate 8—B.) Sphagnum moss was placed in the top tray to retain moisture, and the bottom tray was left empty to lessen shock on the eggs. The space below the bottom tray was filled with wet sphagnum moss for moisture retention and prevention of shock. Each transport case held approximately 50,000 eggs, and when fully loaded with eggs, trays, and ice, weighed about sixty pounds.

Ice Container. The ice container was a wooden box of approximately the same size as the transport case, but with less insulation, and large enough to hold a fifty-pound block of ice, which was used to replenish ice trays in transport cases. (Plate 8—A, No. 5.)

With the equipment listed above—two transport cases filled with eggs, one ice container, and twenty planting trays—it was possible for one man with two pack animals and a saddle horse to deliver and plant 100,000 eggs to any point within one to four days travel time from the packing base. Since it requires a nine mule pack train and two men to plant 25,000 fry at a distance usually not greater than twenty-five miles, the above described method reduces the planting costs by about two-thirds. Further, if pack stock cannot get through, or is not available, eggs may be carried by man pack—a feature of particular importance in Primitive Areas where trails are not plentiful. The transportation of eyed eggs is particularly satisfactory when use is made of an airplane. On this forest, airplane transport of supplies and equipment into outlying areas has been found efficient. It was an easy matter to add a transport case or two of eggs to one of the regular loads. Eggs may be carried long distances in this way, and from the point of unloading, the cases may be carried still greater distances by either mule or man pack.

PLANTING

At the planting site the eggs were transferred from the transport trays to the planting trays, and all dead eggs were removed. (Plate 9—B.) The lids on the planting trays were nailed down, and each tray tied to a bush or log with baling wire and anchored over moving water.

Eggs were planted in waters with temperatures ranging from 42° to 64°F. Above 60°F. higher mortality resulted—whether because of temperature or oxygen relation is not known. At lower

temperatures hatching time was considerably increased. Best results were obtained in water ranging from 50° to 54°F.

A few special precautions in handling eyed eggs are worthy of note. The transport cases should be kept upright and level so that the eggs will not pile up and be crushed, suffocated, or jounced about unnecessarily. The ice trays must be kept filled to maintain proper temperature and moisture. Planting trays should be securely anchored and lids well-fitted so that the eggs cannot be washed out. Some loss was incurred by the breaking of the anchor wires, allowing the trays to float into slow eddy water where there was not enough agitation to secure the best egg hatch. This difficulty was largely overcome by using heavier wire. Allowance must be made for the swelling of the lids after immersion in the water. Otherwise they will buckle and allow the eggs to escape. Experience showed that lids could not be fitted *inside* the tray, since swelling in water would spring the tray, and cause a loss of eggs. The lids were therefore fitted to cover the tray flush with the outside edge of the sides. When nailed in this manner, expansion did not cause enough swelling to lose eggs through cracks. Allowance must be made for the variable water-levels of mountain lakes and streams so that the planting trays will not be stranded on dry land, buried in silt and sand, or turned upside down. The principal cause of losses was fluctuations in water level.

The plants made during 1938 were experimental to determine the possibilities in the use of eyed eggs. During that season on the Flathead Forest a total of 420,800 eyed eggs were distributed as follows:

Condon District—33,600 eyed eggs (planted from the road)

Schafer District—117,000 eggs (carried by pack animals)

Big Prairie District—141,000 eggs (carried by plane to the Big Prairie Ranger Station and distributed from there by pack animals)

Lower Swan District—129,200 eggs (carried by pack animals)

The first experimental eyed-egg planting was made June 20–22, 1938, in creeks tributary to the Swan River. Six of the plants made at that time are listed below. The percentage of hatch was based on counts of unhatched eggs left in trays.

Place of Plant	*No. of Eggs*	*Percentage of Hatch*
1. Cilly Creek	4,800	25
2. Goat Creek	4,800	85
3. Dog Creek	4,800	90
4. Condon Creek	4,800	90
5. Condon Creek	4,800	25
6. Cooney Creek	4,800	90

Plants 1 and 5 showed a low hatch due to a cloudburst, causing the creeks to carry heavy burdens of silt which smothered the eggs. The other plant on Condon Creek (No. 4) at a considerable distance below No. 5 was not appreciably affected by the silt.

Eggs planted in Miner Creek and Flotilla Lake on the Schafer Ranger District on July 4 were examined on July 12. The tray of eggs planted in Miner Creek where it comes out of the ground from Flotilla Lake was just starting to hatch. About ten per cent of the eggs were dead. Approximately five per cent of the live eggs were hatched, and hatching was taking place rapidly at the time of the inspection.

Of the five trays planted near the

inlet of the lake, one tray was submerged in about two feet of water at a temperature of approximately 51°F. About ten per cent of the eggs in this tray were dead. The remainder had apparently hatched, and the small fishes could be seen on the bottom of the lake in great numbers.

One tray was floated in the inlet in about eighteen inches of slow running water at a temperature of 50°F. Fifteen per cent of the eggs in it were dead and the rest had apparently hatched. Many small fishes could be seen on the bottom.

One tray was set out in the lake, floating in about six feet of water with the temperature at 64°F. Thirty per cent of these eggs were dead. Apparently the remainder had hatched, but due to depth of the water, none could be seen on the bottom.

One tray was floated at the inlet in about twelve inches of slow running water at a temperature of 50°F. About five per cent of these eggs were dead, and great numbers of live fishes could be seen on the bottom.

One tray was floated in about two feet of fast running water in the inlet some two hundred feet from the lake. Two per cent of these eggs were dead. The temperature at this point was about 50°F. Some fishes could be seen on the bottom of the creek around this tray, but the water was so swift it is believed that most of them were washed downstream and scattered to the extent that it would have been hard to find any number of them.

An analysis of these plants shows that the best hatches were obtained in rapidly flowing water at the inlet of the lake where the temperature remained close to 50°F. The tray situated in comparatively quiet water in the lake at 64°F., showed a relatively high percentage of unhatched eggs. It has not been possible to make a further check to determine whether egg loss was primarily due to high temperature or to oxygen deficiency.

As to the third lot of eggs distributed from the Schafer Ranger Station on August 7–8, a summary of results is included in the following tabulation:

Tray	Number in tray	Location of tray	Loss in transit	Loss since planting	Total loss	Percentage of loss
1	10,000	Confluence Dolly Varden & Schafer Creeks	500	250	750	7.5
2	9,400	1½ mi. up Dolly Varden Cr.	101	200	301	3.2
3	9,400	2 mi. up Dolly Varden Cr.	155	47	202	2.2
4	9,400	3 mi. up Schafer Creek	150	50	200	2.2
5	9,400	3 mi. up Schafer Creek	287	6	293	3.1
6	5,000	3 mi. up Lodgepole Creek	11	57	68	1.4
7	4,100	4 mi. up Lodgepole Creek	53	50	103	2.5
8	5,000	3½ mi. up Lodgepole Creek	51	50	101	2.0
Totals	61,700		1,308	710	2,018	3.2

As noted in the table the loss in transit amounted to 2.1%; that loss since planting to 1.1%; and the total loss at the time of observation to 3.2%. At the date of the last inspection many of the eggs had not yet hatched. Although at

that time it was estimated that 98% had hatched in Dolly Varden and Schafer Creeks, while only about 30% had hatched in the colder Lodgepole Creek.

Throughout the period of observation during the hatching and early "floating" stage of the young fish, careful attention was given to the presence and effect of predacious animals. In one instance several large leeches were found in a tray. In another it was noticed that caddis fly larvae concentrated near a tray and that they were feeding upon parts of eggs which had been damaged in handling. Nothing, however, indicated that predation was an important factor or that different casualties occurred among the young fry than are experienced when fry are stocked directly. Instances of other fishes eating the fry or eggs were not observed on any of the plants.

Following the experimental plants during 1938 a comprehensive stream and lake survey was made and a detailed stocking program was prepared. In 1939, with augmented equipment and a larger supply of eggs, the first steps toward fulfillment of this program were taken when 932,300 eggs were planted. Five hundred thousand of the eggs were supplied by the U. S. Bureau of Fisheries from Yellowstone National Park; the remainder were furnished by the State Fish Hatchery at Somers, Montana. The results of this season's work are shown in table on page 309.

In order to show the obstacles which may be overcome by the use of eyed eggs, the following day-by-day description of the longest shipment and most difficult plant is included here.

July 22, 1939. Fifty thousand eyed eggs from the Yellowstone Park Hatchery were trucked fifty miles to Gardiner, Montana, and shipped by express 450 miles to the Montana State Fish Hatchery at Somers.

July 24. The eggs arrived and were packed in a transport case.

July 25. The eggs were trucked thirteen miles to Kalispell, Montana, and became part of an airplane shipment to the Big Prairie Ranger Station in the South Fork Primitive Area, about 100 miles distant.

July 26. The eggs were transported fifteen miles by pack horse from Big Prairie Ranger Station to Shaw Creek Guard Station.

July 27. The transport trays, removed from the case and wrapped, together with a supply of ice, in a saddle blanket, were back-packed seven miles and planted in George Lake, a barren body of water 200 acres in extent in the South Fork Primitive Area, where the water temperature was 54°F.

The total loss from the time the eggs were shipped from Yellowstone Park until they were planted was 2.4%. Unfortunately it was not possible to make a final check, but that the planting would be successful was indicated by the fact that the eggs began to hatch as soon as they were placed in the water.

This is an extreme example and was undertaken primarily for the purpose of determining whether eggs could be transported such distances and under such conditions. In an average operation, 100,000 eggs were planted in three days. In the usual plant the eggs were taken from the Somers hatchery,

EYED EGGS PLANTED 1939
FLATHEAD AND LEWIS AND CLARK NATIONAL FORESTS

Date 1939	Stream or lake	Number planted	Percentage eggs lost in transit	Percentage hatch	Remarks
6/ 7	West Fork Pentagon Creek	28,200	1.9	98.0	
6/ 7	Pentagon Creek	23,500	1.9	93.0	
6/ 7	Wall Creek	23,500	2.3	86.0	
6/ 8	Sp. Bear River	28,200	1.5	96.8	
6/10	Abbott Creek	9,400	0.04	unknown	tray lids buckled; eggs lost
6/13	Morrison Creek	23,500	3.5	73.0	some trays stranded;
6/14	Flotilla Lake	51,000	2.0	63.0	water went down
6/14	Lodgepole Creek	14,100	2.6	50.0	
6/14	Whistler Creek	14,100	3.0	98.0	
6/27	Mid Creek	28,200	0.01	96.5	
6/27	Black Bear Creek	23,500	0.03	96.3	
6/28	Helen Creek	28,200	0.1	94.0	
6/28	Hungry Creek	23,500	0.2	94.5	
6/28	South Fork Sun River—Lewis and Clark Forests	103,000	0.8	93.2	
7/ 3	Rock Creek—trib. North Fork Sun River—Lewis and Clark Forests	103,000	1.0	90.0	
7/ 6	Bond Lake	9,400	5.4	60.0	eggs too near hatching time; many
7/ 6	Trinkus Lake	9,400	6.5	60.0	were broken
7/ 6	Hall Lake	18,800	5.0	60.0	
7/ 6	North Lost Creek	9,400	2.0	50.0	
7/ 6	Goat Creek	9,400	2.1	50.0	
7/12	Olar Lakes	58,000	0.7	[2]	no check[1]
7/12	Sunburst Lake	42,000	0.9	[2]	no check[1]
7/13	Wrong Creek—trib. North Fork Sun River—Lewis and Clark Forests	81,000	0.1	94.7	
7/18	Gray Wolf Lake	100,000	0.4		no check[1]
7/25	South Fork Flathead River	20,000			[3]
7/27	George Lake	50,000	2.4		no check[1]
Total		932,300			

[1] Those plants not checked were in inaccessible places and the checking of them would be expensive.

[2] Approximately ¼ of these eggs were hatched at the time of planting; the fish were alive and in good condition.

[3] This case of 50,000 eggs was thrown from a pack horse and broken. About 20,000 live eggs were saved and planted.

trucked sixty to one hundred miles, mule packed from ten to twenty-five miles and planted, wherever practicable, close enough to other forest activities to be checked after hatching.

CONCLUSION

In conclusion it should be pointed out that the use of eyed eggs as a method of stocking remote areas is still experimental to the extent that none of the fishes have yet had time to reach maturity. Checkers have observed hundreds of young fishes in the neighborhood of the plants weeks after they were made, but the ultimate success of the method will depend on how many fishes reach legal size. Since there is ade-

quate proof of a high percentage of hatched eggs, and since apparently healthy fry have been seen at planting sites, there is no good reason to believe that the percentage of survival of fry obtained through the planting of eyed eggs should not be fully as high as that of fry transported direct from a hatchery. There is a possibility that fry from eyed eggs may show a higher percentage of survival than would be shown by fry subjected to the rough treatment of transportation and unfavorable temperature changes. Since a number of lakes stocked have no surface outlets it should be possible to correctly appraise the value of the method within the next two years.

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TWO APPARENTLY FATAL GROUSE DISEASES

Ian McTaggart Cowan

During the year 1938–39 there were forwarded to me by the British Columbia Game Commission through Game Warden R. S. Hayes of Duncan, V. I., specimens of grouse exhibiting lesions produced by two apparently fatal diseases.

Scabies

(Plate 10—B)

On October 19, 1938, we received a Ruffed Grouse (*Bonasa umbellus sabini*) shot near Duncan that had both legs heavily infected with the mite *Cnemidocoptes mutans*. The general appearance of the legs was that characteristic of this malady in the domestic fowl. The scales were elevated by the accumulation of granular material under them and there was some hypertrophy of the dermal and epidermal tissue at the base of the toes. Later in the month of October three more birds with this infection from the same locality and one from Clinton, B. C., forwarded by K. Racey of Vancouver, were received. In two of these birds, hypertrophy of the epidermal tissue of the tarsi and feet had proceeded to such a degree that the tarsi were three or four times normal size and in one instance ulceration had commenced. The most advanced case I have examined was a bird shot at Duncan on October 30, 1938. In this individual the entire unfeathered portion of both legs and feet were involved and the scales and claws had been sloughed along with the terminal phalanges on the two third digits. Hypertrophy of the tissue of the feet had rendered these members utterly useless either for scratching or for perching, even walking must have been difficult, if not impossible. In this case, also, an area about an inch in diameter on the breast over the keel of the sternum was infected with the same mite. This bird was extremely emaciated and could not have survived more than a few days.

In August, 1939, a California Quail (*Lophortyx c. californica*) was found in a dying condition near Victoria and brought to the laboratory. This bird's legs were infected with *Cnemidocoptes* and presented an almost identical picture to those of the most severe cases encountered in the Ruffed Grouse.

Avian Cancer

(Plate 10—A)

Hunters shooting sooty grouse (*Dendragapus f. fuliginosus*) on Hill 60 near Cowichan Lake in the autumn of 1939, reported that many of them were diseased. On September 17, 1939, three grouse shot at the above locality were sent to the laboratory. They had tumors in the skin of the head; in one instance the tumor involved the naked area surrounding the right eye and rendered that eye useless. In a second case the area about both eyes was affected, one eye being completely occluded and the other partially so. The worst case of the three had tumors around both eyes and also at the base of the upper mandible. Limited vision was still possible from one eye but it seemed that it

would have been just a matter of time before blindness and subsequent starvation would have killed the bird.

The same hunter that sent in these specimens reported shooting two other grouse out of the same covey that had the heads so badly distorted that he did not like to touch them and left them where they fell.

Dr. G. A. McCurdy, Director of the Department of Pathology at the Royal Jubilee Hospital, Victoria, B. C., made histological preparations of these tumors and diagnosed them as low grade papillary carcinomata composed of well differentiated squamous epithelial cells. Infiltration of the deeper tissues indicated a low degree of malignancy.

The presence of this disease in epidemic proportions in a localized area suggests that it is contagious. It seems probable that the causative organism is a filtrable virus and that transmission is by biting flies. However, we have not the facilities available for establishing this experimentally.

Ian McTaggart Cowan
British Columbia Provincial Museum
Victoria, B. C.
Canada

A (*Left*)—Head of Sooty Grouse showing malignant tumor of the periorbital skin.
B (*Right*)—Foot of Ruffed Grouse showing results of infestation by the mite *Cnemidocoptes mutans*.

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THE INTERSECTION METHOD OF COUNTING ANIMALS

Samuel A. Graham

In wildlife management the need for accurate and simple methods of estimating the populations of wild animals is continually before us. New methods and refinements of old procedures are being proposed and tested. The intersection method of locating animals by their calls or other sounds is one that offers considerable promise and has been used in work near Ann Arbor to make spring counts of a number of different birds, as pheasants, mourning doves, and quail. The test on drumming grouse described here serves as an illustration of the possibilities of this method and is presented with the hope that others may try it under different conditions on various suitable animals. Such counts are of value in determining the location of breeding birds in the spring. Over extensive areas, where the local variations in sex ratio are averaged out, or on smaller areas where the proportion of the sexes is known, it may be used as a basis for estimating total spring populations.

The method is based on the old principle of locating a point by intersecting lines projected in the direction of the unknown point from two or more known points, a standard method of locating forest fires. In locating fires the bearing of the unknown from the known points is determined by sight, but in the method described here for locating the grouse it is determined by hearing. Naturally this cannot be as accurate as sighting over an alidade. Nevertheless, it has been found that drumming grouse and other birds can be located by this procedure with reasonable accuracy.

The habits of the drumming grouse in the spring appear to be well suited to this method. For an hour or even longer before daylight the male grouse drums frequently, about once every 20 to 30 seconds, from approximately the same location. After it becomes light the birds move about and the drummings are more irregularly spaced in time and the same bird may drum from several places. For instance, a bird flushed from his drumming spot at daybreak flew several hundred yards and in a few minutes drummed from the new location. Therefore, any accurate count of drumming grouse must either be made before light, or be based on many observations, checked, and rechecked to eliminate duplications. We have had similar experience in counting singing passerine and other birds and have found that accurate counts must be made before light in the morning.

The test count of drumming ruffed grouse here described was conducted on a quarter section of land near Ann Arbor, Michigan, known as Mud Lake Swamp. Observation points that could easily be located in the dark were established and observers were placed at these stations at least one hour before daylight. Each man recorded direction, relative distance, and time of each drumming. Later the bearings from the known points were plotted on a type map, the points of intersection indicating the approximate locations of the drumming birds.

Observations in the spring of 1939 were made on two different mornings using six stations on the first morning and five on the second. Two or more bearings on each bird could have been obtained by using only four stations, two on the west and two on the east side of the area. Each morning seven drumming birds were located. Although a strong north wind on the second morning made the stations on the north side of the area useless, each of the seven birds observed on the first morning was located within 300 feet of the same spots where it had been located the first morning. In 1940 the test was repeated by different men. The results were astonishingly similar to those of the previous season. Birds were drumming from each point located in 1939. When plotted on the same map, the different observations for each drumming point could be encompassed by circles varying in radius from 30 to 150 feet. The degree of accuracy was inversely proportional to the distance between the listening and drumming points. In addition to the drumming stations located in 1939, two additional points were being used in 1940. By 6:00 A.M. the drumming became sporadic and somewhat inconsistent in direction, indicating that the birds were moving about, presumably feeding.

Each observer remained at his station throughout the drumming period. As a practical procedure this would seldom be justifiable because it would require from four to six men to census a quarter section. Experience indicates, however, that during the period of frequent drumming, when the counts must be made, only a few minutes at each station is adequate to determine the direction of the drumming birds. Thus it is entirely feasible for one man to move from station to station recording bearings from each. In this way a single observer could make the necessary observations on a large area. If conditions are such that transportation from station to station can be made with an automobile or even on horseback the time factor is even less of a limitation. Such facilities permit the survey of large areas by this method.

The difficulty of locating the direction of drumming is not so great as might be anticipated. Although the sound is illusive and an observer may be uncertain of the direction of the first drumming, this uncertainty disappears after listening to repeated drummings from the same spot. None of the men taking part in our grouse counts has had any difficulty in locating the direction of sounds with satisfactory accuracy.

This description of the intersection method of counting animals is presented as a suggestion to wildlife technicians who may find it useful and who may try the procedure under different conditions and on various suitable species. Such tests will almost certainly result in the development of improvements and will bring out weaknesses that might easily be missed in work confined to a single locality. However, the method shows promise of being very useful as a means of quickly and accurately determining breeding populations of animals which call or produce other recognizable sounds that can be heard from a distance.

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A STUDY OF MONTHLY VARIATIONS IN THE NUTRITIVE VALUE OF SEVERAL NATURAL WINTER DEER FOODS[1,2]

Henry Hellmers

Much work has been done to determine the natural food plants that are eaten by deer. Clepper (1931), working in Pennsylvania, concluded that deer at one time or another feed upon practically all the common trees and shrubs that grow in the forest. On the other hand, very little research has been undertaken to determine the nutritive content of these plants, and as a result very little is known about their comparative food values. The importance of such knowledge to a proper evaluation of deer food is obvious. At the present time the Department of Forestry at the Pennsylvania State College is carrying on a research project on silvicultural practices affecting the food of white-tailed deer (*Odocoileus v. virginianus* and *O. v. borealis*) which includes a study of the seasonal feeding habits of the animals. In connection with the project, it was deemed advisable to attempt a nutritional study of some of the foods to form a basis for later interpretation of seasonal preferences.

Very little analytical work that may be applied directly to the present study has been done on the variations in the chemical composition of woody plants through the dormant season. Study of the translocation of materials in fruit trees, however, revealed marked seasonal shifts in the amount of reserve materials in the young shoots (Miller, 1931). A distinct change in protein nitrogen and in sugars was found by Traub (1927) to take place in 2- to 3-year-old apple shoots during the dormant season. Upon analysis of the fruit spurs of three varieties of apple trees, Hooker (1920) noted considerable alteration with respect to the content of nitrogen, sugars, and total carbohydrates through the resting period; of special interest was the uniform trend in the chemical changes.

In dealing with plants not so closely related as those with which Hooker (1920) worked, uniformity in trend was not observed. Thus Gordon and Sampson (1939) found that although species within a plant group have characteristic composition levels, the variation in chemical values in the life cycle of plants of a given species, is greater than that between the various species of the plant group at any single growth stage. Both this work and that of Mulay (1931) on seasonal changes of nitrogen compounds in the current year's shoots of Bartlett pear, indicated that significant variations occur during the winter.

A very thorough analytical study was made of the reserve materials in the beech tree (*Fagus silvatica*) by Gau-

[1] Paper No. *10* from the Pennsylvania Cooperative Wildlife Research Unit, the Pennsylvania State College and The Pennsylvania Game Commission, cooperating with the U. S. Bureau of Biological Survey.

Authorized for publication on *January 22, 1940*, as Paper No. *951* in the journal series of The Pennsylvania Agricultural Experiment Station.

[2] A thesis submitted to The Pennsylvania State College in partial fulfillment for the degree of Master of Science, June 1939.

mann (1935) at Zurich, Switzerland. Seasonal changes in the buds and twigs were followed throughout the course of the year, and both variations and trends were exhibited during the dormant period.

Davenport (1937) in Michigan analyzed and reported on the chemical composition of 15 species of deer browse. His paper also summarized chemical analyses of various common woody species eaten by deer. A general comparison was thus obtained of the nutritive values of the plants that presumably applied to the entire winter season. Considerable differences in nutrient content were shown by the various wild plants, all reported upon being very low in protein as compared with feeds used for domestic animals.

The primary objective of the present investigation was to determine whether a sample collected at any given time during the winter would be representative of the nutritional value of that species for the entire season. This information was sought to determine the amount of work necessary to obtain truly comparative values.

A secondary objective was to compare the chemical compositions of the species of browse collected with each other and with those of some of the more important pasture grasses, and thus to throw some light on their relative nutritive values.

The following species of woody plants were used in this study: Hazelnut (*Corylus americana*), prairie willow (*Salix humilis*), American aspen (*Populus tremuloides*), sweet fern (*Myrica asplenifolia*), panicled dogwood (*Cornus paniculata*), bear scrub oak (*Quercus ilicifolia*), and chestnut scrub oak (*Quercus prinoides*). They were growing on a Morrison sandy loam (Mooney, 1910) area of 4,000 acres that extends through the middle of Nittany Valley in Centre County, Pennsylvania. The area is known locally as "The Barrens" and supports a population of 1 deer to about 18 acres. The plant community has a wide distribution and has been estimated to cover about 2,000,000 to 3,000,000 acres in Pennsylvania alone. It is made up chiefly of scrub oak, with patches of many other species of shrubs. Pitch pines that have survived many fires and fast-growing aspens are the only trees that stand out above the low, dense tangle of smaller vegetation (Plate 11). One species, red maple (*Acer rubrum*), was obtained on Leading Ridge of Tussey Mountain, which lies on the southern edge of Nittany Valley. The growth on this area is a forest of the oak-hickory type. Red maple was included in the study, in addition to the species collected in "The Barrens," because it is a species commonly occurring over the State and is recognized as a favorite food of deer (Clepper, 1931).

The samples were collected during the first half of each month from November 1937 to April 1938, inclusive. Only the shoots of the previous growing season were used. To eliminate surface moisture, collections were made on days that had been preceded by a 36-hour period of no precipitation. The samples were collected at random, care being taken to gather not more than two twigs from the same plant in any one month. At each sampling, 150 to 200 twigs of each species were collected from approximately 75 to 150 plants. The Committee on Methods and Chemical Analysis for the Society of Plant

A view of "The Barrens" showing the dense growth of scrub oaks topped by aspens and pitch pines.

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Physiology (1926) considers such a randomized series of samples large enough to give an average sample of each species.

Immediately after being brought to the laboratory, the twigs were cut with shears into pieces about one-fourth of an inch in length. One hundred grams of each species was then weighed out and placed in drying cabinets at a temperature of about 70° to 80°C. This quick-drying treatment was used to stop enzymatic action, so that the material could be stored without significant change in its chemical composition (Thomas, 1927).

The samples were next run through a Wiley mill and placed in sealed jars. The mill powdered and mixed the material so efficiently that a 2-gram sample was considered representative of the whole terminal growth, i.e., buds, bark, and wood, for any given month of collection.

The standard methods of the Association of Official Agricultural Chemists (1935) were used to determine moisture, ether extract or crude fat, crude fiber, protein, and ash or mineral matter. The nitrogen-free extract was obtained by difference based on dry weight. All analyses were run on duplicate 2-gram samples weighed out to four decimal places.

Because of the presence of volatile oils, the approved indirect method of determining the ether extract was employed. It was also found necessary to extract the samples for a 24-hour period instead of the usual 18 hours.

The resulting data—summarized in Tables 1 to 8, inclusive—show the percentile chemical composition of the eight species of plants. As previous work (Miller, 1931) has shown that there is a translocation of foods in plants from points of storage to points of utilization, it is not surprising that marked variations in composition between months are evident. The most significant feature of the results of the present study, however, is that the variations from month to month for the different species do not always parallel each other in either intensity or direction of fluctuation. The fact that some of the constituents exhibit a distinct seasonal trend is also striking.

As shown in the graph (Fig. 1), there is a general downward trend in the pro-

TABLE 1

PERCENTAGE COMPOSITION OF RED MAPLE SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	54.6	6.4	2.1	34.9	53.7	2.9
December	53.2	6.4	7.1	34.0	50.0	2.5
January	54.7	5.2	3.2	38.1	51.3	2.2
February	53.3	5.4	2.8	40.7	48.7	2.4
March	55.8	5.6	2.5	36.6	53.3	2.1
April	55.6	5.2	4.7	37.5	50.5	2.1
Averages	54.5	5.7	3.7	37.0	51.3	2.4

TABLE 2

PERCENTAGE COMPOSITION OF HAZLENUT SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	47.6	6.6	2.8	31.7	55.2	3.7
December	47.8	6.5	2.7	33.2	54.1	3.5
January	48.1	6.7	2.4	33.7	53.7	3.6
February	49.4	6.7	2.6	36.0	51.4	3.4
March	47.9	5.3	2.9	36.2	52.0	3.7
April	48.2	4.9	3.3	34.1	54.1	3.6
Averages	48.2	6.1	2.8	34.2	53.4	3.6

tein content of the twigs of most of the species during the dormant period. There are also marked monthly fluctuations, which do not, however, obscure the general trend. It is a rather generally accepted fact that the high proportion of protein in twigs at the beginning of the dormant period is obtained by reabsorption from the leaves just before they fall (Gordon, 1939; Sampson, 1935).

Digestibility and nutritional value of feeds have been shown to vary indirectly with the crude fiber content (Maynard, 1937). That element in all the species tested in the present study rises through the winter months (Fig. 2).

The more digestible carbohydrates are represented in the nitrogen-free extract, which through the winter season exhibits a decrease (Fig. 3) that is also indicative of a reduction in nutritional value.

The data summarized in the graphs (Figs. 1, 2, and 3) seem to indicate that the three most important food constituents in twigs have distinct seasonal trends. These are in each case toward a lowering of the nutritive value. They are not steady but are characterized by sharp rises and declines. At times the value for one species may rise above or fall below that of another, thus giving a false indication of their relative values for the winter as a whole. For example,

TABLE 3

PERCENTAGE COMPOSITION OF PRAIRIE WILLOW SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	49.2	7.7	4.9	33.1	51.4	3.0
December	47.5	7.5	3.9	34.1	51.7	2.8
January	48.0	6.7	4.3	35.1	51.1	2.8
February	46.8	7.9	6.0	34.4	49.0	2.8
March	48.0	7.6	4.2	37.0	48.6	2.7
April	49.0	7.7	4.7	36.1	48.6	3.0
Averages	48.1	7.5	4.7	35.0	50.1	2.9

TABLE 4

PERCENTAGE COMPOSITION OF AMERICAN ASPEN SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	45.7	7.8	12.2	27.1	49.5	3.4
December	48.2	8.2	10.7	25.9	52.3	2.9
January	48.6	7.7	9.5	28.0	51.9	2.9
February	48.3	7.9	10.1	28.4	50.8	2.8
March	47.8	8.3	8.1	29.0	51.6	3.1
April	47.5	7.3	8.4	30.8	50.7	2.8
Averages	47.7	7.9	9.8	28.2	51.1	3.0

samples of hazelnut and prairie willow taken in February and tested for crude fiber content indicated that hazelnut had the higher proportion. This, however, is not a true comparison for the entire winter season, as can be seen from the graph (Fig. 2).

Because of the volatile oils, gums, and resins found in the different species, the fat analyses were the most difficult to make and the least reliable. American aspen, the only species to exhibit a considerable amount of fat (Fig. 4), also showed a progressive decline in this constituent. The other spe-

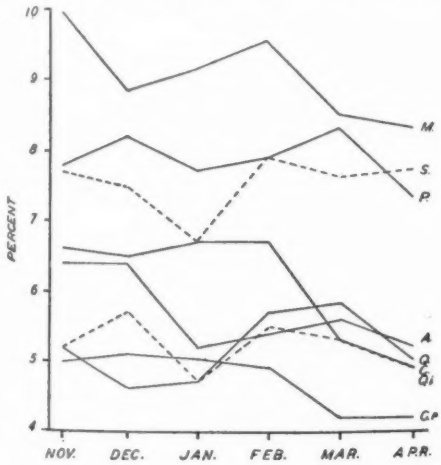

Fig. 1. Monthly protein content in percentage of dry weight for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P., American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

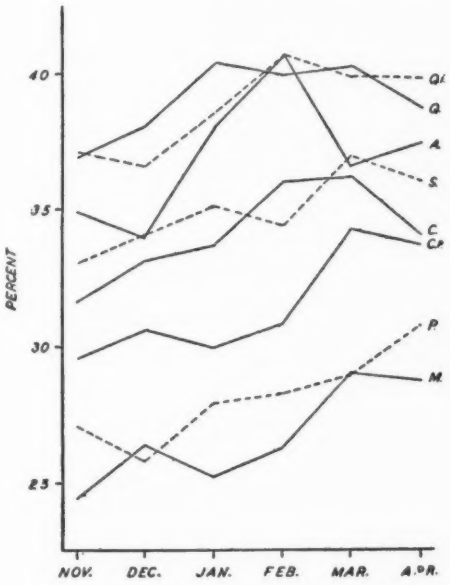

Fig. 2. Monthly crude fiber content in percentage of dry weight for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P., American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

TABLE 5

PERCENTAGE COMPOSITION OF SWEET FERN SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	48.0	10.0	3.4	24.4	60.3	2.0
December	46.1	8.8	3.0	26.5	59.6	2.1
January	49.9	9.1	3.4	25.2	60.2	2.1
February	48.5	9.5	3.2	26.3	58.9	2.2
March	43.7	8.5	2.7	29.1	57.9	1.9
April	47.1	8.3	3.5	28.8	57.5	1.9
Averages	47.2	9.0	3.2	26.7	59.1	2.0

cies contained relatively insignificant quantities of fat, and if a trend is present, it is small.

The mineral content, or ash, remained almost constant for all species, never varying more than 1 per cent and showing only a very slight downward trend (Fig. 5). This result is in general agreement with ash analyses of buds and twigs reported by Gaumann (1935).

The largest monthly fluctuations were found in the moisture content (Fig. 6). This is probably best accounted for by the great differences in

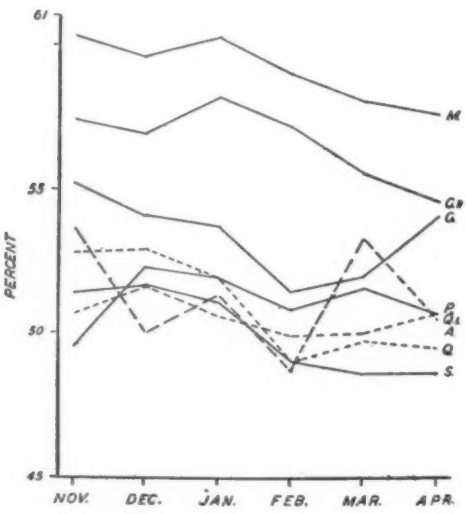

Fig. 3. Monthly nitrogen-free extract content in percentage of dry weight for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P., American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

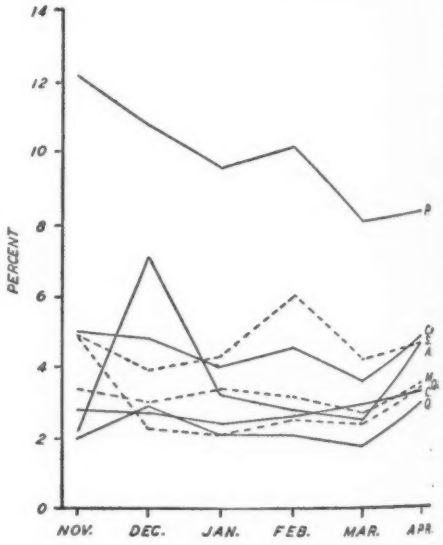

Fig. 4. Monthly fat content in percentage of dry weight for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P., American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

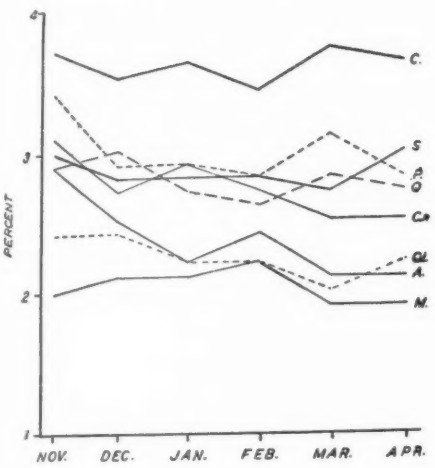

Fig. 5. Monthly ash content in percentage of dry weight for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P. American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

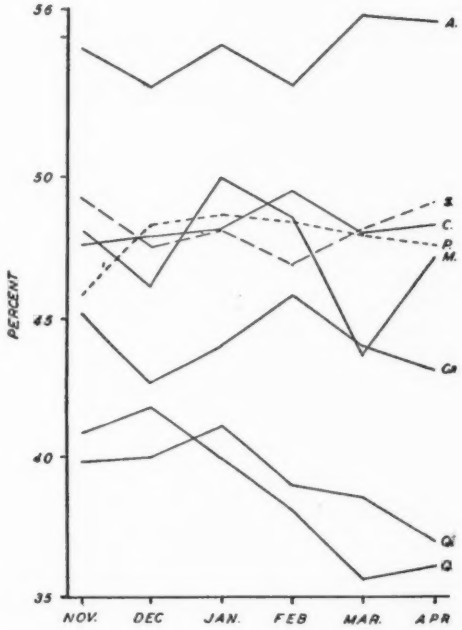

Fig. 6. Monthly moisture content in percentage for each species: A., red maple; C.p., panicled dogwood; C., hazelnut; M., sweet fern; P., American aspen; Q.i., bear scrub oak; Q., chestnut scrub oak; S., prairie willow.

the drying power of the air during various weather conditions. Although for most species the fluctuations are very irregular and do not exhibit marked trends, those for oaks do indicate a downward trend. This accords with field observations that the twigs of these species became very brittle toward the end of the dormant season.

DISCUSSION

It is apparent that in a comparative study of the nutritional values of different species of browse, the most difficult

TABLE 6

PERCENTAGE COMPOSITION OF PANICLED DOGWOOD SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	45.2	5.0	5.0	29.6	57.3	3.1
December	42.7	5.1	4.8	30.6	56.8	2.7
January	44.0	5.0	4.0	30.0	58.1	2.9
February	45.7	4.9	4.6	30.9	57.0	2.7
March	44.0	4.2	3.6	34.3	55.5	2.5
April	43.2	4.2	4.9	33.8	54.6	2.5
Averages	44.1	4.7	4.5	31.5	56.6	2.7

TABLE 7

PERCENTAGE COMPOSITION OF BEAR SCRUB OAK SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	39.8	5.2	4.9	36.9	50.7	2.4
December	40.0	5.7	2.3	38.1	51.6	2.4
January	41.1	4.7	2.1	40.4	50.6	2.2
February	38.9	5.5	2.5	40.0	49.9	2.2
March	38.5	5.3	2.4	40.3	50.0	2.0
April	37.0	4.9	3.4	38.8	50.7	2.2
Averages	39.2	5.2	2.9	39.1	50.6	2.2

problem is to obtain representative samples. Those taken at monthly intervals are not comparable, and even samples taken at the same time do not always show true relative values. It is impractical to run separate monthly analyses of a large number of species, but this difficulty could be overcome by collecting samples of equal size at monthly intervals and making a composite sample of the collections for an entire season for analysis. If this is done, the monthly samples should be collected in duplicate in order to form parallel series that may be analyzed separately to detect any sampling error.

In comparing the nutritional value of the woody plants with that of grasses, bluegrass (*Poa pratensis*) and timothy (*Phleum pratense*) were used. Bluegrass was selected because it ranks highest in food value among the pasture grasses (Morrison, 1938), and timothy was chosen because it is the most widely used species. Both of these grasses are found in this region.

Their nutritive values were reported on in Agricultural Biochemistry by Dutcher (1932). The data for the woody species used for the block diagrams (Figs. 7 and 8) are averages of the six analyses made of each species over a 6-month period.

That sweet fern is undoubtedly the

TABLE 8

PERCENTAGE COMPOSITION OF CHESTNUT SCRUB OAK SHOWING MONTHLY VARIATIONS THROUGH THE DORMANT SEASON OF 1937–1938

Month	Moisture	Oven dry basis				
		Protein	Ether extract	Crude fiber	Nitrogen free extract	Mineral matter
November	40.8	5.2	2.0	37.1	52.8	2.9
December	41.8	4.6	2.9	36.6	52.9	3.0
January	39.9	4.7	2.1	38.5	51.9	2.7
February	38.1	5.7	2.1	40.7	48.9	2.6
March	35.6	5.8	1.8	40.0	49.7	2.8
April	36.1	5.0	3.0	39.9	49.5	2.7
Averages	38.7	5.2	2.3	38.8	51.0	2.8

most desirable species of this group of eight from a nutritional standpoint, is evident from the block diagrams (Figs. 7 and 8). In the three most important constituents—protein, nitrogen-free extract, and crude fiber—it compares quite favorably with bluegrass and is even better than timothy. It must be remembered in these comparisons that the low proportion of crude fiber shown by sweet fern is desirable.

The other woody species, listed according to their general nutritive value, would fall in a descending order, as follows: American aspen, hazelnut, panicled dogwood, prairie willow, red maple, and finally bear scrub oak and chestnut scrub oak of almost equal value. All these woody species are better than bluegrass and three are better than timothy in nitrogen-free extract.

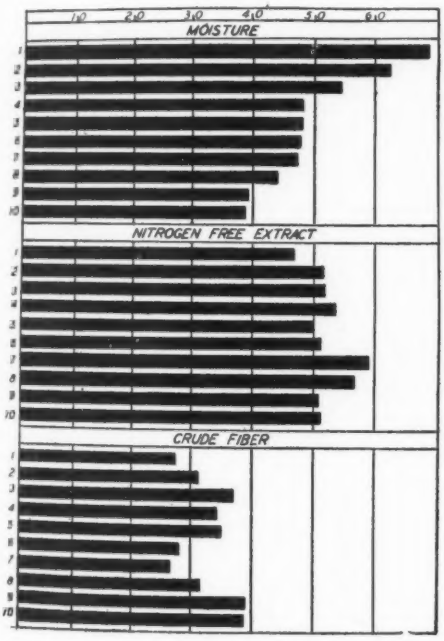

Fig. 7. Average percentage composition of the species as to moisture nitrogen free extract and crude fiber: 1., bluegrass; 2., timothy; 3., red maple; 4., hazelnut; 5., prairie willow; 6., American aspen; 7., sweet fern; 8., panicled dogwood; 9., bear scrub oak; 10., chestnut scrub oak.

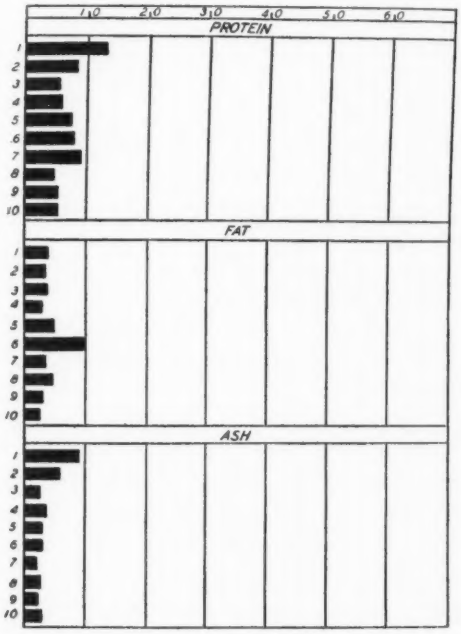

Fig. 8. Average percentage composition of the species as to protein, fat, and ash: 1. bluegrass; 2., timothy; 3., red maple; 4., hazelnut; 5., prairie willow; 6., American aspen; 7., sweet fern; 8., panicled dogwood; 9., bear scrub oak; 10., chestnut scrub oak.

This ranking is based solely on the nutritive values as determined by chemical analyses. A true appraisal of the value of these feeds would have to take adaptability to digestion into consideration, also.

SUMMARY

Samples of eight species of woody plants browsed by deer were collected at monthly intervals and analyzed

chemically to detect variations in their composition.

Marked differences were found, especially in protein, nitrogen-free extract, and crude fiber, all of which exhibited trends indicating reduction in nutritive value through the winter.

As a result of this study, it is believed that a representative index to the nutritive value of winter browse may be most easily and most satisfactorily obtained by collecting material monthly and analyzing composite samples made by mixing the original samples of each species in equal proportions. The samples should all be collected at least in duplicate, so that errors in sampling may be determined. This method tends to reduce errors that would be caused by fluctuations and seasonal trends.

A few of the species analyzed compared very favorably in chemical composition with bluegrass and timothy. Most species, however, were considerably below these two grasses in nutritional qualities.

ACKNOWLEDGMENTS

The writer is greatly indebted for the guidance of Dr. J. L. Deen, formerly Associate Professor of Forestry, under whose direction this project was begun, and for the helpful suggestions and constructive criticisms of Dr. W. C. Bramble, Associate Professor of Forestry, and Dr. H. A. Meyer of the Department of Forestry of The Pennsylvania State College.

The analytical work was conducted under Dr. H. O. Triebold, of the Department of Agricultural and Biological Chemistry, whose continuous assistance and encouragement are deeply appreciated.

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OBITUARY

Robert Henry Stobie, who served as Director of the New Hampshire Fish and Game Department for nearly five years, died on March 14, 1940 at the Margaret Pillsbury Hospital in Concord, N. H., after a short illness. Mr. Stobie was admitted to the hospital two weeks previously for observation and soon after suffered a heart attack from which he did not recover. His untimely death was deeply felt in official circles in New Hampshire and among sportsmen throughout New England.

Being an ardent follower of outdoor life, his work in the Fish and Game Department reflected his splendid ideal, and his zealous interest in his duties lifted the department to the highest plane of efficiency it has ever known. Never a person who sought the limelight, hunters and fishermen knew him more by the results he achieved; persons who were fortunate enough to have met him saw the qualities that made him an ideal head of a department for sportsmen. If there was ever a man who made a hobby of his vocation it was Robert Stobie, and never did he stint of his time or personal finances to promote the cause he loved, the improvement of the state's wildlife resources and man's enjoyment therein. He was an honest gentleman and a true sportsman.

Mr. Stobie was born in Garbridge, Scotland, son of William H. and Martha (Horne) Stobie, June 19, 1885. At the age of seven years, he came to the United States with his parents, who settled at Gardner, Maine. He was educated in public schools and was a graduate of Colburn Classical Institute and Keist's Business College, Waterville, Maine. He entered the paper manufacturing business, and at the age of 25 years became superintendent of Hollingsworth and Whitney Company mills at Madison, Maine.

In 1911 he married Anne Pitts of Waterville, Maine. They had three children, Mrs. Gordon (Martha) Van Buskirk, Miss Marie Stobie, and William Stobie.

Mr. Stobie moved to Hooksett, New Hampshire, in 1919 where he purchased a large dairy farm near the banks of the Merrimack River. His farm later became famous for its herds of pure bred Guernsey cattle and Oxford Downs sheep. He was elected representative to the New Hampshire legislature from Hooksett in 1933, and became chairman of the House Fish and Game Committee in that session. He was appointed Director of the Fish and Game Department on July 7, 1935. He was a member of Waterville, Maine, lodge of Masons, was formerly a member of the Suncook Lions' Club, and was president of the New Hampshire Field Trial Club for ten years. Mr. Stobie was former State doubles trap shooting champion.

He inaugurated and carried through a biological survey of all the lakes and streams in the State of New Hampshire. This program—a three-year project has saved the State thousands of dollars, and for the first time has given a New England state a complete biological picture of what needs to be done to improve and stock its waters for the sportsmen.—J. Paul Miller.

CORRESPONDENCE

The Editor prefers to publish here rather than in Wildlife Society Information two communications out of the ordinary though they may be for THE JOURNAL OF WILDLIFE MANAGEMENT. Both relate to the philosophy of our field—a subject promised consideration in our opening statement of policy but to date given only a modicum of attention. The essay on "The Animal Census" may help some to avoid taking too seriously the mathematical aspect of population studies, while the "Song of the Gavilan" may happily convince any of us, not yet sufficiently impressed, of the necessity of an ecologic and four-dimensional or time-including outlook upon life.

THE ANIMAL "CENSUS"

The abilities of observing clearly, and correctly interpreting observations are of prime importance in connection with the management of wild land. The game manager is likely to be a wildlife specialist. He must be, as well, a fair generalist on the other important uses of wild land. Timber management, wildlife management, and recreational management are an inseparable trinity not too solidly balanced upon a complicated foundation of ecological laws. Grazing is a fourth specialty in the West, and in all intensely agricultural regions. If these premises are sound, and if my own observations and interpretations convey a modicum of truth, there is something wrong with the popular game "census."

A "census" according to Webster's International Dictionary, is an enumeration. One might "census" the deer on a section of land, but the best he could do on a million-acre tract would be to translate sample area counts into a population estimate. As a term applied to wild animals, I trust "census" may soon be relegated to limbo, but I am not restricting these comments to the criticism of a word. The "census" may be just as objectionable by any other name if it is prosecuted with too much enthusiasm and too little thought.

An inventory of the existing stock seems to be one of the first essentials in any reorganized business. There is an admirable effort under way to modernize the business of producing wildlife, so this simple logic undoubtedly stimulated the game manager's urge for counting. No one questions the necessity for an inventory on any area to be put under management. The necessity for a count, however, depends upon what is going to be done about it. If he is not going to do anything about it, a "census" is perhaps something to keep the budding game manager busy. That, too, is logical if he does not know what else to do.

Personal experience convinces me that a form of "barometer" reading will serve to indicate the population pretty well to a trained and experienced observer. The old trapper looked for "fur signs." He did not make a "census" of the foxes, martens, otters, or beavers in the locality. The "sign" showed a high reading on his hypothetical fur barometer, so he built a cabin and cruised out his trap line. The

properly trained game manager can read "signs" the same way. He may read that a species is abundant, common, occasional, or rare, noting also that the richness of the environment and the time of year determines the quantitative definitions of those terms. Ten deer to a section might be abundance in one habitat, while it would indicate scarcity on optimum range. Several other descriptive terms seem desirable. "Saturated" is clearly satisfactory to designate super-abundance, and the necessity for its use may portend famine or disease that will cause a die-off unless a heavy harvest is gathered. "Remnantal" is a word I find in Webster after attempting to coin "remnantial," to show a condition between rarity and extermination. In Minnesota, for example, the otter is rare. The marten and fisher are remnantal and presumably will be exterminated. Terms are unimportant; any committee could decide upon them arbitrarily; it is the conditions described by the names that are important.

It is my belief that population trends are far more important than numbers, and that they must always be considered in relation to environmental trends. Your position may make little difference in the long run, if you know the course you are following, your rate, and your stamina. In very intensive management a "census" may be desirable. Counting, however, will not increase something that is scarce, or decrease something that is abundant. The principal value of an exact count to the skilled game manager is proof to politicians and skeptics that he knows what he is talking about. In actual practice, it is the fur catch or the game take that needs counting. If a National Forest herd can stand a kill of ten thousand deer a year and no decrease in the deer population be shown by the "barometer," it does not especially matter how many deer there are. On the other hand, if there is a severe winter kill, a closed season probably will be advisable the following fall. A count backs up an already known "barometric" reading, but does little more.

Counts may be especially fallacious during the periods of peak populations of cyclic animals. The more or less cyclic muskrats are something of an exception to this rule as they are, in the case of lodge rats, at least, easy to estimate. A fur take record helps to prove the fluctuations. Ruffed grouse counts, upon which maximum scientific effort has been expended, I feel are greatly overemphasized, so far as measurable value is concerned. Any good woodsman can tell whether or not grouse are plentiful enough for an open season when he covers some ground in the woods. If grouse are scarce, he knows it. A few days' study tells the tale to a single skilled observer over many sections of land. Where conditions are reasonably homogeneous, as in the grouse lands of the Lake States, Northern New York, Northern New England, and Eastern Canada, it is not especially difficult to classify grouse as to abundance. Among grouse, even the kill count means little during a cyclic peak. A limit can frequently be shot then with a .22 target pistol in some of the northern areas just mentioned. In the Lake States, in many instances, not 10% of the choicest grouse land has a hunter in it. My experience on some National Forests indicates that the short season

on grouse is of no consequence so far as affecting the population is concerned. The birds have too much advantage of cover for the hunters to make an impression. At the opposite extreme, near cities, where there are ten hunters working over ten acres during each of ten days, I hardly know what to think of a "census." If the hunters are skillful, the grouse will all be killed.

In closing, a population "norm" for varying environments may rate some emphasis. Whether population abundance is expressed by a number, or by a descriptive term, it should always be considered in relation to environmental quality. Silvicultural site qualities have frequently been expressed as 1, 2, and 3, with a 1 plus site for good agricultural land that for some reason was not cleared, and something lower than site 3, that was perhaps capable of growing a crop of pulp wood in a hundred and fifty years, and might build up in a thousand years, but was out of the picture so far as immediate silvicultural practice was concerned. Something quite parallel is necessary in a study of animal population, and kill must be regulated, in some manner, according to habitat productivity, to say nothing of habitat accessibility.

Management would be simple, indeed, if we could all observe clearly and interpret our observations properly. In the meantime, I would have game managers remember that an inventory of capital stock is not necessary unless you know what you are going to do about it. In a pre-census study the "barometer" reading of population may be so clear that a numerical count is superfluous.

My question as to the importance of the game census is aimed at the future rather than at the past or present. Considering the whole world, there are no new principles of wildlife management. Game management and grazing management both antedated timber management in Europe. Our North American Indians had some pretty clear ideas on the harvesting of the game crop, being especially interested in carrying on that harvest on the other tribe's hunting grounds. The Chinese were in the game business at the dawn of their civilization. They are in it yet, but there is nothing intensive about it. Game management is intensive in Scotland. It will be intensive here.

Making a count so accurate that it may be called a "census" may help the beginner who cannot read the population barometer. This help may be needed if that beginner cannot observe clearly nor interpret what he observes. When the age of clarity is reached, perhaps the harvest may still have to be counted, but an estimate, rather than a census, will do pretty well for the determination of the volume of capital stock.

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Winona, Minnesota

SONG OF THE GAVILAN

The song of a river ordinarily means the tune that waters play on rock, root, and rapid.

The Rio Gavilan has such a song. It is a pleasant music, bespeaking dancing riffles and fat rainbows laired under mossy roots of sycamore, oak, and pine. It is also useful, for the tinkle of waters so fills the narrow canyon that deer and turkey, come down out of the hills to drink, hear no footfall of man or horse.

Look sharp as you round the next bend, for it may yield you a shot, and thus save a heart-breaking climb in the high mesas.

This song of the waters is audible to every ear, but there is other music in these hills, by no means audible to all. To hear even a few notes of it you must first live here for a long time, and you must know the speech of hills and rivers. Then on a still night, when the campfire is low and the Pleiades have climbed over the rimrocks, sit quiet and listen for a wolf to howl, and think hard of everything you have seen and tried to understand. Then you may hear it—a vast pulsing harmony—its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rhythms spanning the seconds and the centuries.

The life of every river sings its own song, but in most the song is long since marred by the discords of misuse. Overgrazing first mars the plants and then the soil. Rifle, trap, and poison next deplete the larger birds and mammals; then comes a park or forest with roads and tourists. Parks are made to bring the music to the many, but by the time many are attuned to hear it there is little left but noise.

* * * *

There once were men capable of inhabiting a river without disrupting the harmony of its life. They must have lived in thousands on the Gavilan, for their works are everywhere. Ascend any draw debouching on any canyon and you find yourself climbing little rock terraces or check dams, the crest of one level with the base of the next. Behind each dam is a little plot of soil that was once a field or garden, sub-irrigated by the showers which fell on the steep adjoining slopes. On the crest of the ridge you may find the stone foundations of a watch tower; here the hillside farmer probably stood guard over his polka-dot acrelets. Household water he must have carried from the river. Of domestic animals he evidently had none. What crops did he raise? How long ago? The only fragment of an answer lies in the 300-year-old pines, oaks, or junipers which now find rootage in his little fields. Evidently it was longer ago than the age of the oldest trees.

The deer love to lie on these little terraces. They afford a level bed, free of rocks, upholstered with oak leaves, and curtained by shrubs. One bound over the dam and the deer is out of sight of an intruder.

One day, by aid of a roaring wind, I crept down upon a buck bedded on a dam. He lay in the shade of a great oak whose roots grasped the ancient masonry. His horns and ears were silhouetted against the golden grama beyond, in which grew the green rosette of a mescal. The whole scene had the balance of a well-laid centrepiece. I overshot, my arrow splintering on the rocks the old Indian had laid. As the buck bounded down the mountain with a goodbye wave of his snowy flag, I realized that he and I were actors in an allegory. Dust to dust, stone age to stone age, but always the eternal chase! It was appropriate that I missed, for when a great oak grows in what is now my garden, I hope there will be bucks to bed in its fallen leaves, and hunters to stalk, and miss, and wonder who built the garden wall.

Some day my buck will get a 30-30

in his glossy ribs. A clumsy steer will appropriate his bed under the oak, and will munch the golden grama until it is replaced by weeds. Then a freshet will tear out the old dam, and pile its rocks against a tourist road along the river below. Trucks will churn the dust of the old trail on which I saw wolf tracks yesterday.

* * * *

To the superficial eye the Gavilan is a hard and stony land, full of cruel slopes and cliffs, its trees too gnarled for post or sawlog, its ranges too steep for pasturage. But the old terrace-builders were not deceived; they knew it by experience to be a land of milk and honey. These twisted oaks and junipers bear each year a crop of mast to be had by wildlings for the pawing. The deer, turkeys, and javelinas spend their days, like steers in a cornfield, converting this mast into succulent meat. These golden grasses conceal, under their waving plumes, a subterranean garden of bulblets and tubers, including wild potatoes. Open the crop of a fat little Mearns's quail and you find an herbarium of subsurface foods scratched from the rocky ground you thought barren. These foods are the motive power which plants pump through that great organ called the fauna.

Every region has a human food symbolic of its fatness. The hills of the Gavilan find their gastronomic epitome in this wise: Kill a mast-fed buck, not earlier than November, not later than January. Hang him in a liveoak tree for seven frosts and seven suns. Then cut out the half-frozen "straps" from their bed of tallow under the saddle, and slice them transversely into steaks. Rub each steak with salt, pepper, and flour. Throw into a Dutch oven containing deep smoking-hot bear fat and standing on live oak coals. Fish out the steaks at the first sign of browning. Throw a little flour into the fat, then ice-cold water, then milk. Lay a steak on the summit of a steaming sourdough biscuit and drown both in gravy.

This structure is symbolic. The buck lies on his mountain, and the golden gravy is the sunshine which floods his days, even unto the end.

Food is the continuum in the Song of the Gavilan. I mean, of course, not only your food, but food for the oak which feeds the buck who feeds the cougar who dies under an oak and goes back into acorns for his erstwhile prey. This is one of many food cycles starting from and returning to oaks, for the oak also feeds the jay who feeds the goshawk who named your river, the bear whose grease made your gravy, the quail who taught you a lesson in botany, and the turkey who daily gives you the slip. And the common end of all is to help the headwater trickles of the Gavilan split one more grain of soil off the broad hulk of the Sierra Madre to make another oak.

* * * *

There are men charged with the duty of examining the construction of the plants, animals, and soils which are the instruments of the great orchestra. These men are called professors. Each selects one instrument and spends his life taking it apart and describing its strings and sounding boards. This process of dismemberment is called research. The place for dismemberment is called a university.

A professor may pluck the strings of

his own instrument, but never that of another, and if he listens for music he must never admit it to his fellows or to his students. For all are restrained by an ironbound taboo which decrees that the construction of instruments is the domain of science, while the detection of harmony is the domain of poets.

Professors serve science and science serves progress. It serves progress so well that many of the more intricate instruments are stepped upon and broken in the rush to spread progress to all backward lands. One by one the parts are thus stricken from the song of songs. If the professor is able to classify each instrument before it is broken, he is well content.

Science contributes moral as well as material blessings to the world. Its great moral contribution is objectivity, or the scientific point-of-view. This means doubting everything except facts; it means hewing to the facts, let the chips fall where they may. One of the facts hewn to by science is that every river needs more people, and all people need more inventions, and hence more science; the good life depends on the indefinite extension of this chain of logic. That the good life on any river may likewise depend on the perception of its music, and the preservation of some music to perceive, is a form of doubt not yet entertained by science.

Science has not yet arrived on the Gavilan, so the otter plays tag in its pools and riffles and chases the fat rainbows from under its mossy banks, with never a thought for the flood that one day will scour the bank into the Pacific, or for the sportsman who will one day dispute his title to the trout. Like the scientist, he has no doubts about his own design for living. He assumes that for him the Gavilan will sing forever.

ALDO LEOPOLD
University of Wisconsin
Madison, Wisconsin

NOTES

Ernest G. Holt, Chief of the Biology Division of the Soil Conservation Service, has been granted leave of absence from the U. S. Department of Agriculture for a period of four or five months in order that he might accept an invitation from the International Health Division of the Rockefeller Foundation to collaborate in studies designed to clear up some of the biological problems surrounding sporadic outbreaks of jungle yellow fever. One of these is the possibility that birds act as a reservoir of the disease. Mr. and Mrs. Holt proceeded to Brazil by airplane July 11 to take up their new duties in country already familiar through several expeditions that have taken them into practically every part of that country.

Some inconsistency in pluralization of the word, fish, has occurred in THE JOURNAL OF WILDLIFE MANAGEMENT in the past and may be noted even in this issue (Doan and West articles). In the future the Editor will endeavor to have the form fishes used whenever a plurality of individuals or species is meant. "One fish," "a mess of fish," or "30 pounds of fish" are examples of legitimate use of the singular form. Authors may aid by following these suggestions.

THE WILDLIFE SOCIETY

Report of the Secretary for the Year Ending with the Fourth Annual Meeting, March 18, 1940

The Regional Representatives have relieved the Secretary of a large part of the burden of the continuing membership campaign this year. Letters of invitation were sent to persons whose names were suggested by members, but follow-up work on these and other prospects was ably carried out by the representatives. Among the many others who have taken an active interest in the matter of building up the membership during the past year, W. L. McAtee and Leonard Wing deserve special mention. The number of new applicants accepted since the last annual meeting, on February 13, 1939, is 140. Fifty-seven were accepted as members for the year 1939, while membership for the remaining 83 began with January 1, 1940.

The total membership of the Society is now 905, including 360 active members and 545 associates. Of these, 73 associates and 30 active members are still in arrears for 1939 dues. In accordance with Article 4 of the By-Laws, which stipulates that "the names of members whose dues are in arrears for two years shall be presented to the Council for action," the latter yesterday reviewed the list of 11 active and 55 associate members delinquent since 1937. As a result of unanimous action, these persons will be notified that unless their dues are paid within a month's time, they will be dropped from the rolls. Resignations were received during the past year from 11 members, while 2 others requested temporary suspension of their memberships.

The Secretary regrets to inform the Society of the deaths of four members: George Charles Embody, Carlos Clyde Goff, Joseph Grinnell and Dewey Richmond Mast. In addition, Harry Milliken Jennison, a member for the year 1937, also passed away.

Active membership applications from about 66 new associate members were referred to the Chairman of the Membership Committee. The file of "old" associates was reviewed twice during the past year and records of about 35 were transmitted to the Membership Committee for consideration of any additional experience or education that might raise their qualifications to the minimum required by the Society for active membership. Records of a number of other associates were also reconsidered at their own request or at the suggestion of members. As a result of this review, 17 associates of more than a year's standing were advanced to the active grade. The total elected during the year was 73, as follows:

Allen, Robert P.
Armfield, Richard B.
Baker, Maurice F.
Barker, Elliot S.
Bateman, Bryant A.
Bellrose, Frank Chapman
Benson, Dirck
Bromley, Albert Warren
Brower, Royce Burr
Carter, Thomas Chauncey
Chalk, John D.
Clevenger, C. Stanley
Coles, Victor
Colton, Harold Sellers
Crissey, Walter F.
Dargan, Lucas McIntosh
Davidson, Joseph Burl
Dellinger, Samuel C.

Dence, Wilford A.
Doremus, Henry M.
Dumont, Philip Atkinson
Featherly, Henry I.
Foster, Frank B.
Franklin, Sydney
Gilfillan, Merrill Clarence
Gower, W. Carl
Grant, Kenneth B.
Griner, Lynn Adell
Hedges, R. Frank
Hempel, Adolph
Henbest, Orrin John
Hicks, Ellis A.
Hicks, Harold W.
Hill, Robert Roy
Holm, Earl Richard
Jackson, Cicero Floyd
Johnson, John Andrew
Kelley, Evan W.
Kelley, William Claude
Kutz, Harry Leon
MacNamera, Lester G.
McCain, Randal
Madsen, Clyde R.
Manges, Edmund D.
Marsh, Albert James
May, Richard Morris
Meadows, Edward L.
Melis, Percy E.
Morton, Glen H.
Nesbit, Ray J.
Newsom, William M.
Osmer, Thomas L. G.
Pollock, Stanley Z.
Perry, Robert
Pough, Richard H.
Pratt, Harold P.
Sanders, Earl
Sanderson, Wilford Edwin
Scheffer, P. M.
Schwartz, John E.
Silver, James
Sime, Palmer Rudolph
Spooner, Charles Stockman, Jr.
Springer, Leonard Martin
Stebler, Adolph Marvin
Stoehr, Henry Arthur
Swift, Lloyd Wesley
Switzenberg, Donald F.
Terrill, Harold Vernon
Van Huizen, Peter Jan
Wilkinson, James T.
Youngren, Russell Alfred
Zimmerman, William E.

With the concurrence of the President and Treasurer, the Secretary made a campaign for subscriptions to THE JOURNAL OF WILDLIFE MANAGEMENT. A series of three letters, to one of which was appended a table of contents of the volume for 1939, was sent to about 1,400 libraries. These letters were drafted by Dr. Frank Thone, for whose interest and help the Secretary wishes to express his appreciation. Approximately 30 libraries entered their subscriptions for 1940 and a number of these purchased sets of back numbers of the JOURNAL. At this moment, paid-up subscribers for the present year total 100. An additional 35 subscribers for 1939 have not yet renewed for 1940, but most of them will undoubtedly do so in the near future. This increase in the number of subscribers to the JOURNAL from approximately 80 at the time of the last meeting to 135 at present, is of considerable importance. All except about a dozen are libraries. These copies of the JOURNAL are therefore brought to the notice of many members of the public who may become interested in the Society itself. This increase in availability means that a major objective of the Society is nearer attainment, that is, publication to effect the "development of all types of wildlife management along sound biological lines."

In accordance with procedure approved by the Council, the Secretary conducted a mail ballot for Regional Representatives. A nominating ballot was mailed November 10, 1939 to be returned by December 10. Returns were counted and names of the three persons in each region receiving the highest number of votes were submitted on the final ballots mailed December 16. On the closing date, January 20, 1940, the elections were as follows:

Region I	Neil W. Hosley
Region II	H. L. Stoddard
Region III	H. D. Ruhl
Region IV	E. R. Kalmbach
Region V	Walter P. Taylor
Region VI	Joseph S. Dixon

From the Secretary's point of view, the news letter "Information" has demonstrated its usefulness and value. It is recommended that the publication be continued, essentially in its present format, although the scope could well be enlarged.

Adequate financial support is necessary for any organization to carry on its work. A large budget is not a necessity for this Society, but there are certain inescapable expenses of operation that must be met. As time goes on and the Society's machinery is shaken down and functions more smoothly, there will also appear greater opportunities for service to the profession of wildlife management. Publication of more articles, of a manual of wildlife management, of Wildlife Review, of a comprehensive bibliography of the literature up to 1935—these and other worthy projects have been urged. Publication requires funds. A subject of concern, therefore, is the matter of delinquency of the dues of 18.8% of the total membership in the past three years. The Treasurer and other officers have given this much thought, but the cause is not evident. An inference is that a considerable percentage of persons who become members of the Society discover that, *for them*, the results are not worth the expenditure of dues. This constitutes a challenge to the organization.

A problem of organization is to find means to distribute the burden of our routine affairs over a sufficient number of shoulders. Of necessity there is some duplication of work for the Secretary and for the Treasurer. Certain records must be kept in duplicate. The processes of acceptance of new members, of membership renewals, of distribution of publications, necessarily concerns both officers and results in considerable overlapping of effort. It seems, therefore, that these two officers have little opportunity to take up more load or to make adjustments. Instead, they create a certain amount of additional work for each other. An obvious solution would be to combine the duties of the Secretary and the Treasurer in one executive officer, and establish, for his assistance, at least two official helpers. Such a scheme would attain its maximum usefulness only if these assistants could be chosen from members living in the same area. This new executive officer should have a voice in selecting them and authority to distribute to them the work of the office. A greater degree of responsibility of this group toward the President and other Council members would be highly advisable. In this way the routine tasks, while being distributed, would at the same time be kept under a single authority. It is suggested that a committee be appointed to examine the feasibility of putting this plan into operation and of reporting on it to the next annual meeting.

Pressure of other duties makes it necessary to request that the office of Secretary be turned over to some other member who can give it the time that its obligations demand. In retiring, I want to thank the many persons who have given such considerate help and to the membership as a whole for overlooking numerous shortcomings. The Society and I are especially obligated to Miss Margaret Muehlhaus for her efficient assistance and for carrying on most of the many routine tasks connected with the office.

Respectfully submitted,

VICTOR H. CAHALANE
Secretary

REPORT OF THE TREASURER FOR THE CALENDAR YEAR 1939

The two major financial policies of The Wildlife Society are: (1) That business will be on a cash basis, using funds as they are received from members and subscribers and not going into debt for an enlarged JOURNAL or for special studies and committee reports, and (2) that the monies received will be largely used to publish THE JOURNAL OF WILDLIFE MANAGEMENT, so that each member may receive most in return for his money.

The financial statement submitted with this report shows that the Society had a balance of $1,509.73 on December 31, 1938 and a balance of $624.52 at the close of 1939. This reduction is the result of spending $652.26 more on the JOURNAL and on Wildlife Society Information than was spent the year before. Of this amount $151.34 was used for Wildlife Society Information. The cost of four issues of the JOURNAL plus reprints and nominal editorial expenses was $2,552.19.

Although more money was spent on

FINANCIAL STATEMENT
For the Year 1939

BALANCE (December 31, 1938)	$1,509.73	
RECEIPTS (From Active and Associate Members and Subscribers)	2,381.15	
TOTAL BALANCE AND RECEIPTS*		$3,890.88
DISBURSEMENTS:		
General Administration		
Stationery and printing	$ 146.55	
Postage, registered mail, telegrams, etc.	298.59	
Secretarial assistance	71.02	
Buffet Supper—Detroit	28.00	
Exchange, returned checks, etc.	11.67	
Treasurer's bond	5.00	
Refunds	2.00	
Publications		
JOURNAL OF WILDLIFE MANAGEMENT (4 issues)	2,505.34	
JOURNAL OF WILDLIFE MANAGEMENT Reprints	34.47	
JOURNAL OF WILDLIFE MANAGEMENT Editorial expenses	12.38	
Wildlife Information (2 issues)	151.34	
TOTAL DISBURSEMENTS		$3,266.36
BALANCE (December 31, 1939)		$ 624.52

* Total receipts are not a product of 1939 dues only, as there have been some late 1937 and 1938, and some early 1940, dues added.

publications, some was saved on General Administration. During 1938 the Society spent $771.09 for this purpose. In 1939 the amount was reduced to $562.83 although there was an increase in the activities of Regional Representatives on Society business and especially in contacting delinquent members. A part of the reduction in cost has been due to the increased unpaid assistance by the secretaries of the Treasurer and Secretary of the Society.

Dues from members and income from subscribers has been coming in rapidly since January 1, 1940 and the Society now has a balance of $1,681.86.

WARREN W. CHASE
Treasurer

REPORT OF THE MEMBERSHIP COMMITTEE

During the first year of its work, in 1937, the Membership Committee found it necessary not only to evaluate the qualifications of candidates but to develop certain minimum standards of membership based upon the relatively meager indications of the Society at its St. Louis meeting. These standards, published in the April 1938 issue of the JOURNAL, were accepted by the Society at its Baltimore meeting in 1938. In 1939, at Detroit, the Membership Committee further clarified the existing standards with respect to experience. These ideas were published in the April 1939 issue and have been utilized during the last year in judging qualifications. At the present time, then, the basis for rating candidates depends upon: (1) Statements in the Constitution of the Society, (2) the recommendations of the Membership Committee referred to above, and (3) the report of the Committee on Professional Standards published in the JOURNAL in April 1939.

With these guides, the Committee has appraised 66 new applications and has recommended that 40 of the new candidates be made active members and 26 associate. In addition it has gone over with the Secretary all the filed applications of members heretofore in the associate class and selected 26 applications for reconsideration. Of these 18 were recommended to the Council for active membership, the others remaining as associates.

The Committee feels that rating of applications was much easier this year than formerly partly because most of the borderline cases were solved before this year and partly because of the increasing definiteness of the Society's standards as mentioned above.

There are two types of applicants, however, whose rating remains difficult. The first is the man who is a wildlife administrator with relatively little training in the wildlife management field and who may be supervising the activities of active members of the Society, but whose experience in the wildlife field is difficult to separate from his general administrative and other duties. It is the Committee's opinion that candidates of this class should be judged on the basis of accomplishment as distinguished from experience. A second type of difficult case is the man who is not professionally engaged in the

wildlife management field but who is intensely interested and active in it. The Committee feels that cases of this kind will probably always be difficult and that action of the Council in individual cases will help gradually to build a precedent for their classification, unless the Committee on Standards can make definite pronouncements covering them.

The Committee has been asked many times why certain individuals are associate members rather than active. The Committee is always glad to have such queries made since some at least have resulted in reconsideration of members and in a few cases election to active membership. But by far the majority of these questions have been answered at once by the statement either that: (1) The associate member has not paid his dues, in which case he cannot be considered for active membership, or (2) the associate member wishes to remain an associate member and specifically does not want active membership. It is felt highly important for the Society to recognize that there are a number of associate members of this latter class.

The committee recognizes that the present method of rating candidates is by no means ideal, but it is at least a practical and workable method that has resulted in relatively few injustices. It may be pointed out again that the Membership Committee has continued in its belief that its responsibilities should involve only the application of standards set up by the Society, to the qualifications of candidates for membership. Whether standards should be changed or modified is beyond the province of the Committee to decide, but it believes the present method of application of standards to be adequate.

RICHARD GERSTELL
JAMES MOFFITT
CLAUDEOUS J. D. BROWN
WILLIAM R. VAN DERSAL
Chairman

REPORT OF THE COMMITTEE ON PROFESSIONAL STANDARDS

A proposal has been submitted to your Committee, to the effect that the Society should consider the question of yearly recognition of the most significant paper or papers in our field. While cash prizes seem to be, for the present at least, out of the question, it was suggested that a citation in the JOURNAL or something of the sort might be the means of according this recognition.

Your Committee has considered the proposal carefully and endorses it, with the recommendation, however, that it be placed in the hands of a committee that will decide upon any limitations as to subject, medium of publication, age or status of the author, and other matters; this committee would also select the judges and administer the plan if it is approved by the Society.

Therefore, to place the question before the house, your Committee moves that the Society approve in principle a plan whereby the most outstanding paper or papers in the field of wildlife ecology or management be recognized by an appropriate citation or certificate at the next annual meeting; the conditions and all administrative details to be left to a committee appointed by the

incoming President. (This motion was seconded and passed.)

A year ago, your Committee announced its intention of studying the matter of civil service practices in relation to wildlife work. At that time, in a preliminary report, the Committee made certain general statements, that remain the Committee's opinion but which have been amplified and supplemented by the year's discussion. The Committee now hopes to be able to lay the foundations of a policy for the Society, to submit the principles and recommendations involved to the Society at a later meeting, and, if they are endorsed, to do everything in its power toward securing their adoption by the agencies concerned, insofar as practical limitations permit.

Your Committee feels, however, that its studies have not yet progressed far enough to warrant the assembling and presentation of concrete figures and recommendations. The purpose of this report, therefore, is simply to tell the Society what inquiries are under way, what other matters are being kept in mind, and what its policy during the coming year is expected to be, whether the present Committee remains in office or is replaced by another group.

Since last fall the Committee has been in touch with the President's Committee on Civil Service Improvement, and has obtained from that group a large amount of significant data relating to federal work in wildlife and related fields. We propose to send to the President's Committee a copy of the present report.

In the belief that our objectives are sound training, fair selection, security, and opportunity, and that civil service arrangements are at present the most important (though not the only) means to these ends, the first task the Committee has undertaken is to state clearly and fully the objectives of its study. Errington is charged with this responsibility, with assistance from the other committee-members.

The second task is to learn as much as possible about present civil service arrangements in the federal bureaus and in the states. Taylor, through his long experience in the federal civil service, has already compiled a large amount of what the Committee needs to know about the distribution, scope, and operation of the federal system. Ruhl and Hawkins have done the same for the states by communicating with them individually.

Since the civil service in the states is probably less well-known to the Society than that of the federal government, your Committee proposes to publish some of the state information during the coming year. The preliminary inquiry is leading to a classification of states on the basis of: (1) Existence of a state system, a departmental system, or no system; (2) general rating of the scope and effectiveness of the system; and (3) its application to wildlife positions. Most of the information has been assembled; it will be checked by the full Committee, then referred to the states for rechecking. After that, it will be presented to the Editor, in the belief that it will be of interest and value to both the Society and the state departments.

As its work goes on, the Committee is concerning itself with such conditions as tenure, advancement, elimination, retirement, and the like. These, how-

ever, though important in the Committee's final report, cannot be discussed at the present time.

The third task which your Committee has set for itself is an evaluation of civil service examination practices. The question asked at some time or other by all wildlife men is, "Do the civil service examinations test the knowledge and qualifications that we believe to be most essential to the conduct of the job?"—whether management, research, or some special phase of either one.

In recent years some of the examinations—notably the Junior Biologist examinations because they are most widespread—have evoked some criticism as to scope, emphasis, form of questions, time, frequency, and other features. The members of your Committee have no doubt contributed their share of these criticisms. However, the Committee feels that it should attempt to consider the matter, at least in part, from the standpoint of the state and federal civil service authorities, whose first question, quite properly, would be, "What do the wildlife specialists suggest as means of improving the situation?"

Therefore, without waiting for this question to be asked, the members of your Committee have assigned themselves the task of preparing, as individuals, *sample* examinations for the general grade of Junior Biologist. The Committee feels that by doing this a person can best show what he thinks about several things: (1) The relative importance of the several fields of subject-matter; (2) the relative emphasis upon personal tests, tests of basic knowledge, and tests of knowledge of its application; (3) the place of "objective" and "essay-type" questions in such an examination; (4) the desirability of options (or even of separate examinations) to display knowledge of special fields, with the corollary question of whether to establish more than one civil service register—general and special; (5) the duration of the examination when all essentials have been included; and other points.

In this undertaking the Committee bespeaks the assistance of the other members of the Society, and it hopes that many members will prepare and submit to the Committee such sample-examinations. It proposes to share with the Society in another progress report the results of these attempts. In preparing them, one should not be influenced by present practical considerations, but he should consider what ought to be, since this is what we should hope to approach.

In this connection your Committee is agreed that as many as possible of the examination questions should be released after the examination is over, as a guide to future educational policy. It is realized that this is not always feasible—for example, in the case of some sets of "objective" questions; but it believes that the more comprehensive questions could and should be available to teachers and students, as they regularly are in a number of colleges and universities. This would be one form of interchange of ideas between the hiring, examining, and training agencies which in the past has not been as free as it should be.

An important part of your Committee's study, headed by Edminster, is an attempt to answer the very perti-

nent question: "How close a correlation exists between a man's actual accomplishment on the job, as rated by his superiors, and several other things—*e.g.*, his civil service examination-grade, his scholastic rating, his extracurricular experience, and the like?" It is entirely possible that the present examinations and courses are giving highest ratings to those most likely to succeed on the job; on the other hand, this may not be so; in either case, we need to know the answer.

Your Committee has examined carefully the reports on civil service made by the Society of American Foresters and its committees, in order to decide the points of agreement and disagreement between the foresters and the wildlife men. In nearly all respects the Committee is in agreement with the points made, and it is realized that there should be increasing cooperation between the groups in these two professions that are interested in the operation of civil service systems.

Thus your Committee's report this year is a general progress report and no more. The Committee believes that the whole study is one of the most important that can be made at this stage, and it is predicated on the basic assumption that wildlife management is a profession in its own right, while at the same time an important adjunct to forestry, soil conservation, and many other fields.

* * * *

Additional note: On March 19, the day after this report was presented to the Society, the members of the Committee met at the Mayflower Hotel, Washington, D. C., with Mr. Lewis B. Sims, technical assistant to the President's Committee on Civil Service Improvement.

Respectfully submitted,
RUDOLF BENNITT, *Chairman*

COMMITTEE:
Rudolf Bennitt
Frank C. Edminster
Paul L. Errington
Arthur S. Hawkins
Carl L. Hubbs
Ralph T. King
Aldo Leopold, *ex officio*
H. D. Ruhl
Herbert L. Stoddard
Walter P. Taylor

MINUTES OF THE FOURTH ANNUAL MEETING AT WASHINGTON, D. C., MARCH 18, 1940

The meeting was opened at 8:30 P.M. with an address by President Aldo Leopold. At the latter's conclusion the meeting went into its business session. The Secretary's report was read and accepted. F. M. Baumgartner read for himself and William J. Howard the report of the Auditing Committee, which found the Treasurer's accounts in order and recommended that a check be made at three-year intervals by professional auditors. Acceptance was voted. The Treasurer's report was read by Warren W. Chase and was likewise accepted. The President then called for reports from the Regional Representatives. Neil W. Hosley for Region I described the unsatisfactory status of Section dues, brought attention to the mimeographed sets of regional conference

papers and to the numerous wildlife meetings in his region. There was no report from Region II but Gustav Swanson's written report for Region III was read. This detailed effective work on the membership campaign and gave a brief review of the last Midwest Wildlife Conference. Olaus J. Murie, for Region IV, described how field work had interfered with his program for the Society. He questioned the lack of clear recognition of objectives on the part of wildlife managers in general. No report was forthcoming from Region V but Sumner's written report was read for Region VI, describing greater activity in his area as well as interest in the Society.

(President Leopold was at this point forced to leave the meeting and turned the chair over to Vice-President C. L. Hubbs.)

The Secretary gave a summary of the Council meeting of the previous day. The meeting then approved continuance of "Wildlife Society Information" as at present organized, as well as the reappointment of W. L. McAtee as Trustee for the term expiring with the 1943 annual meeting.

The motion that the next annual meeting of the Society be held at the same time and place as the next North American Wildlife Conference was passed 45 to 16.

Rudolf Bennitt recommended election of H. L. Stoddard to honorary membership which was voted unanimously. E. L. Sumner, Jr., and Phil Goodrum were elected to the vacancies on the Membership Committee caused by the expiration of the terms of E. V. Komarek and James Moffitt. By acclamation W. L. McAtee was re-elected Editor of THE JOURNAL OF WILDLIFE MANAGEMENT. He read his report for the past year which was accepted.

J. E. Shillinger gave a verbal report of the operations of the Program Committee. V. H. Cahalane expressed the appreciation of the Society for the Committee's work and the meeting accepted the report.

Chairman Rudolf Bennitt then presented the report of the Committee on Professional Standards. The meeting voted to adopt the committee's recommendation that the Society approve in principle a plan whereby the most outstanding paper or papers in the field of wildlife ecology or management be recognized by an appropriate citation or certificate at the next annual meeting, the conditions and all administrative details to be left to a committee appointed by the incoming President. At the conclusion of the reading of the report it was accepted and the committee continued. The meeting, by motion, expressed special commendation of the Professional Standards Committee report.

The majority report of the Membership Committee, and a minority statement by E. V. Komarek, were read by Chairman W. R. Van Dersal, who recommended delaying discussion on the latter until after the meeting had had an opportunity to hear the recommendations of the Committee on Constitutional Revision. Upon agreement, Chairman S. A. Graham then presented the committee report which was accepted. After considerable discussion by a number of members, it was voted by a large majority to refer to the Council the changes proposed by the

committee. Following discussion of the two classes of membership, the majority report of the Membership Committee was adopted with only one dissenting vote. The Council was instructed to review the duties of the Secretary and the Treasurer with a view to determining whether uniting these offices and duties would give promise of effecting efficiencies and economies, with report to be made at the next annual meeting. The Nominating Committee report was presented by Chairman Paul Dalke for himself and H. D. Ruhl and the session turned to election of officers. The chair appointed L. E. Hicks and Gardiner Bump as tellers. The balloting gave the following results: President, V. H. Cahalane; Vice-President, Paul R. Needham; Secretary, Frank Edminster; and Treasurer, Warren W. Chase.

Due to the lateness of the hour the meeting accepted the Employment Committee's report without reading. The Society's thanks were extended to the officers for the previous year. The retiring President was requested to submit the address read at the opening of this meeting for publication in THE JOURNAL OF WILDLIFE MANAGEMENT.

Adjournment was at 11:45 P.M.

VICTOR H. CAHALANE
Secretary

THE STATE OF THE PROFESSION[1]

Aldo Leopold

One of the ironies frequent in history is a group of men attempting one thing and accomplishing another. We are attempting to manage wildlife, but it is by no means certain that we shall succeed, or that this will be our most important contribution to the design for living.

For example, we may, without knowing it, be helping to write a new definition of what science is for.

We are not scientists. We disqualify ourselves at the outset by professing loyalty to and affection for a thing: wildlife. A scientist in the old sense may have no loyalties except to abstractions, no affections except for his own kind.

Moreover, some of us entertain heresies and doubts. We doubt whether science can claim the credit for bigger and better tools, comforts, and securities without also claiming the credit for bigger and better erosions, denudations, and pollutions. We doubt whether the good life flows automatically from the good invention.

The definitions of science written by, let us say, the National Academy, deal almost exclusively with the creation and exercise of power. But what about the creation and exercise of wonder, of respect for workmanship in nature? I see hints of such dissent, even in the writings of the scientifically elect—Fraser Darling, for example. Of course, we have always had such writers (David, Isaiah, John Muir) but they were not scientifically elect; they were only poets. Is Fraser Darling only a poet?

The peculiar pertinence of this to our

[1] Address of the President of The Wildlife Society, Washington, D. C., March 18, 1940; directed to be printed in The JOURNAL OF WILDLIFE MANAGEMENT by motion of the Society in annual meeting assembled.

profession is that we deal with science, but we have no prospect of inventing new tools or powers. Our job is to harmonize the increasing kit of scientific tools and the increasing recklessness in using them with the shrinking biotas to which they are applied. In the nature of things we are mediators and moderators, and unless we can help rewrite the objectives of science our job is predestined to failure.

* * * *

I daresay few wildlife managers have any intent or desire to contribute to art and literature, yet the ecological dramas which we must discover if we are to manage wildlife are inferior only to the human drama as subject matter for the fine arts. Is it not a little pathetic that poets and musicians must paw over shopworn mythologies and folklores as media for art, and ignore the dramas of ecology and evolution?

There are straws which indicate that this senseless barrier between science and art may one day blow away, and that wildlife ecology, if not wildlife management, may help do the blowing. We have, at long last, an ecological novel—Peattie's "Prairie Grove." Darling is not the only ecologist whose scientific writings have literary quality. In our profession, and on its fringes, are a growing number of painters and photographers who are also researchers. These intergrades in human taxonomy are perhaps more important than those which so perplex the mammalogists and ornithologists. Their skulls are not yet available to the museums, but even a layman can see that their brains are distinctive.

* * * *

In its external trappings of printed knowledge, our profession has attained in four years a maturity which might well have taken a decade. I refer, of course, to THE JOURNAL OF WILDLIFE MANAGEMENT and the *Wildlife Review*. Some journal papers are still a bit thin, but the average is high and getting higher. No other conservation profession has the equal of the *Wildlife Review*.

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One of the weak points in our profession is the low proportion of private employment. Even among the publicly employed the proportion dealing directly with practice on private lands is small.

I think there are more opportunities in private practice than we foresee.

A few industries are already set to go ahead. The guano industry of Peru has employed an American ornithologist to manage its birds, and thus to put guano on "sustained yield." The number of guano birds on these very small Peruvian islands is nearly as great as the number of ducks in North America. This comparison may help convey the heroic proportions of this venture, and incidentally, the low estate of our ducks.

The Hudson's Bay Company is, I think, about set for fur management in the Canadian Arctic. They must be, for the wild fur is gone. Canadians, I think, will do well to encourage the venture, else they will have more acres on relief than we have. Incidentally, a boom in beavers will do much for the ducks.

Why do large private holdings retain wildlife managers in the Southeast, but not elsewhere? If our profession can give valuable service on strings of quail preserves, why not to other game species in other regions where large holdings exist? At least one reason harks

back, I think, to a lack of respect for private property. In most regions the public puts all landowners, large and small, under moral suasion not to post. The public does not realize that this is moral suasion not to manage.

Some day the hunter will learn that hunting and fishing are not the only wildlife sports; that the new sports of ecological study and observation are as free to all now as hunting was to Daniel Boone. These new sports depend on the retention of a rich flora and fauna. Management of private holdings to rebuild the fauna and flora is one of the opportunities offered our profession today. There is a growing number of private sanctuaries, private arboreta, and private research stations, all of which are gropings toward non-lethal forms of outdoor recreation. But few such gropings are skillful. Wildlife managers, acting in a consulting capacity, could help owners find what they are looking for.

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Some fear that we are getting too much research and not enough management into our journals and (by implication) into our programs. I do not share in this view; in fact, I think the shoe is on the other foot. We know how to manage only a few easy species like deer and pheasants. In other species we know a few fragmentary treatments which are *probably* beneficial, but this is not enough. Until we know more it is proper that a high proportion of our professional effort should go into research.

Too much research, however, is superficial and aimed at quick returns. The high proportion of sporting funds in both the ten unit system and the new Pittman-Robertson structure tends to perpetuate this distortion. So does the low proportion of research groups which have as yet demonstrated capacity to execute more fundamental investigations. So does the series of inter-bureau treaties which confine federal research to a single bureau. Is it not just as illogical to confine wildlife research to a single bureau as it is to confine conservation to a single department?

If anyone doubts that we are trying to eat our research dessert before starting the soup-kettle, let him appraise the national situation in terms of the following questions: In how many species do we know the sex and age composition of a population, and its rate of turnover? In how many species do we have criteria of age? In how many species have we followed the behavior of a sample population for ten years?

The research program is out of balance in other respects. One is the paucity of research of an ecological nature in such groups as rodents where the problem is to manage downward rather than upward. Stockmen and farmers quite naturally want direct action in the form of control, while absentee conservationists protest at any action at all. It is probable that both are wrong, and that the eventual answer in rodents, as in game, lies in indirect environmental manipulation. But where is the research aimed to develop and implement this concept? Concepts do not help to manage land.

The research program is out of balance in that certain kinds of wildlife are omitted altogether; for example, wildflowers and other non-economic vegetation. It would be interesting to see one of the Ten Units get into a huddle with the botany department and propose to the Director of Conservation that something be found out about the

management of lady-slippers in farm woodlots. Would the checkbook snap open or shut?

It is encouraging to note that one erstwhile orphan, innocent of economic utility, is no longer high-hatted by his useful conservation cousins. I refer to rare species.

Lastly, the research program pays too little attention to the history of wildlife, and our system of publications makes no provision for historical monographs. We do not yet appreciate how much historical evidence can be dug up, or how important it can be in the appraisal of contemporary ecology. I have in mind such historical work as that of A. W. Schorger in Wisconsin, most of which is not yet in print. I would like to see the Society set up a basket to receive funds for the publication of historical wildlife monographs. I believe that both the monographs and the funds would eventually be forthcoming.

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One problem which now faces the profession is how to organize extension. I use that word in its agricultural sense, *i.e.*, sending out trained men to help landowners to help themselves.

Most extension efforts in wildlife have been aimed at helping sportsmen to help themselves. It represents real progress to see states like Texas and Missouri sending out young technicians to deal directly with landowners. The coordination of this new enterprise with the parallel enterprises in agriculture and forestry remains to be worked out.

The problem of teaching conservation to laymen is distinguishable from extension only in name. State after state is legislating conservation courses into the curricula of public schools. But where are the local teaching materials, and who is to teach the teachers how to use them?

In those states which have wildlife research units the production of teaching materials is presumably under way, but what of the teaching of teachers? Why do so many universities spend most of their wildlife funds and use their ablest men in training professional managers when the greater need is for wildlife courses for the general student body and for prospective teachers?

These are problems of educational policy far wider than our own profession, but the speed and skill with which they are solved will depend in large degree on the statesmanship of wildlife managers.

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In this little list of unanswered problems and dilemmas there lies concealed, but I hope not undiscovered, a story of almost romantic expansion in professional responsibilities.

Our profession began with the job of producing something to shoot. However important this may seem to us, it is not very important to the emancipated moderns who no longer feel soil between their toes.

We find that we cannot produce much to shoot until the landowner changes his ways of using land, and he in turn cannot change his ways until his teachers, bankers, customers, editors, governors, and trespassers change their ideas about what land is for. To change ideas about what land is for is to change ideas about what anything is for.

Thus we started to move a straw, and end up with the job of moving a mountain.